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TABLE OF CONTENTS ON PAGE TWO

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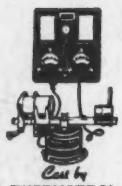

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The Journal of Prosthetic Dentistry

CONTENTS FOR NOVEMBER, 1955

Through the Eyes of the Editor 729

Patient, Dentist, Laboratory Technician—A Cooperative Triumvirate. Chastain G. Porter, D.D.S., Kansas City, Mo. 732

Complete Denture Impression Technique. Ira E. Klein, D.D.S., New York, N. Y. 739

Articulator Mounting by Functional Maxillomandibular Records. Edward J. Ulip, D.D.S., Seattle, Wash. 756

An Analysis of Current Concepts of Occlusion. Vincent R. Trapozzano, D.D.S., St. Petersburg, Fla. 764

The Why and How of Cuspal Harmony in the Lateral Ranges. B. C. Kingsbury, D.D.S., San Francisco, Calif. 783

Comparison of Balanced and Nonbalanced Occlusion of Artificial Dentures Based Upon Distribution of Masticatory Force. Arthur R. Frechette, Captain (DC) USN, Camp Pendleton, Calif. 801

Adaptation and the Hybrid-Prosthesis. Niels Brill, L.D.S., Copenhagen, Denmark 811

Some Anatomic Facts and Fancies Relative to the Masticatory Apparatus. Linden F. Edwards, Ph.D., Columbus, Ohio 825

Discussion. Some Anatomic Facts and Fancies Relative to the Masticatory Apparatus, by Linden F. Edwards, Ph.D. Carl O. Boucher, D.D.S., Columbus, Ohio 840

One-Piece Castings for Fixed Bridgework. J. Gordon Rubin, A.B., D.D.S., and Albert A. Sabella, New York, N. Y. 843

The Implications of Full Coverage Restorative Procedures. Russell C. Wheeler, D.D.S., St. Louis, Mo. 848

Maintenance of Full Coverage Fixed-Abutment Bridges. Julius Caplan, D.D.S., Chicago, Ill. 852

The Readers' Round Table

The Readers' Round Table 855

News and Notes

Announcements 858

Directory

Directory 861

Index

Index 863

(Editorial and Business Communications on page 18)

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THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 5 November, 1955 **No. 6**

THROUGH THE EYES OF THE EDITOR

Chastain G. Porter sounds the keynote for a successful practice of prosthodontics. He points out the fact that the dentist, the laboratory technician, and the patient each have definite responsibilities in prosthodontic service. Each party in this cooperative effort must do his part to the best of his ability in order to achieve the best results. Likewise, none of those involved should be expected to accept the responsibility of either of the others. Harmonious relations will follow naturally if the recommended attitudes are adopted.

Ira E. Klein describes his techniques for complete denture impressions. He reviews some of the early articles on impressions and gives a brief description of the various anatomic landmarks which serve as guides in impression procedures. If these are understood thoroughly, the problems of impression building become more simple. He includes details of procedure which should make the technique relatively simple to follow. However, even with these guides, the dentist much have a sound understanding of the anatomy and physiology of the structures involved, and he must be able to visualize the completed impression as he progresses with the various steps in building it.

Edward J. Ulip discusses the mounting of casts by means of chewed-in maxillomandibular records. He shows that correct jaw relations *can* be made by this procedure, but he is careful to warn that incorrect records also can be made by this procedure. The terms "strained" and "unstrained" apparently cause confusion because they are used to mean different things to different authors. In this instance, they are used to mean a strain in a *posterior* direction. Many authors use them in relation to a strain in a *vertical* direction. He states that the mandible cannot be "forced" too far back. The question arises as to exactly which anatomic structures stop the posterior movement of the mandible. The resistance of the external pterygoid muscle and the temporomandibular ligament have been suggested, but this mechanism has not been clearly demonstrated. One factor is obvious, however. Pressure in a posterior direction applied against the point of the chin will induce a counteracting contraction of the external pterygoid muscles which will tend to protrude the mandible. A comparable reaction may be observed by pressing your index finger against that of someone else. The other person will automatically resist your pressure. Unless the patient is trained or conditioned *not* to resist pressure applied on the chin, an inaccurate maxillomandibular record is likely to result. It is true that patients, when instructed to "bite," will automatically protrude the mandible. It is for this reason that the word "bite" is psychologically bad to use while making centric relation or hinge position records. It would seem to be logical that the basic maxillomandibular relation should be a terminal relation, i. e., the relation for the mounting of the casts should be the most posterior positional relation. Then, in function, the occlusion could never be disturbed by the mandible closing too far back. Whether this relation is called centric relation or the terminal hinge position is immaterial. All other maxillomandibular relations could then be related to this basic jaw position. The method of locating the mandibular position of centric relation is less important than the *fact of its location.* It is important to recognize that "It is the dentist's duty to know, and his obligation to verify, that the jaw relationships delivered by the patient and

mounted in the instrument are free from errors . . . ." No method is foolproof, and even the best of them require eternal vigilance because of the factors which are beyond the dentist's control.

Vincent R. Trapozzano makes an analysis of current concepts of occlusion. He points out the fact that there is a greater interest in occlusion now than ever before because its importance is being recognized. This interest causes more people to think about the problem, and varying concepts are the natural result. He points out the variations in definitions of terms as being the cause of some of the disagreement regarding occlusion. His own definition of centric relation may be criticized because it refers primarily to the "position of the condyles in the glenoid fossae." In reality, it is the relation of the mandible to maxillae that is important, even though the relations of the condyles in their fossae are factors in the maxillomandibular relation. The other components of his definition seem to be sound. There can be little doubt of the part played by the neuromuscular system in this relationship. His comments regarding "rest position" and the differentiation between rest position and centric position should clarify some misunderstanding of the problem. The philosophy expressed in the treatment of malocclusion seems to be valid. The causes listed for inaccurate records made with needle-point tracings explain why some errors in the mounting of casts are developed when tracings are made. He recognizes the terminal hinge axis location as an important record because it is a "border" position to which all other positions can be related. However, while he recognizes that the patient *may* close on the terminal hinge axis, he will close many other times with translatory movements combined with the hinge movement. This seems to be obvious. Because of the complex neuromuscular system which controls mandibular movement, the jaw *can* close from any position and to any other position within the functional range of jaw movement. Therefore, the chewing cycle cannot be designated as a specific pattern which would be constant under all conditions. He points out some misinterpretations of observations of jaw movements that occur during mastication, and presents reasonable arguments for balanced occlusion in dentures. The deficiences of articulators are recognized, but a logical solution is suggested.

B. C. Kingsbury discusses the importance of cuspal harmony in the lateral ranges and a means for obtaining the desired harmony. He discusses the various factors involved in developing cuspal harmony in natural dentitions. He sets up the objectives to be used in this treatment and describes a practical technique for achieving the objectives. The suggested "rules" are understandable and sound.

Arthur R. Frechette reports his studies of the pressures transmitted to the supporting tissues by complete dentures with balanced and nonbalanced occlusions. His test method was devised so it would eliminate almost all of the variables except those in the occlusion. Pressures were measured at six points on the denture base. These points were located so they would be affected by vertical and horizontal movements of the bases, but not in positions where rotational forces would become a factor. Further tests which include these measurements might be illuminating. The results of this experiment do not establish the value of bilateral balanced occlusion during mastication. However, the results are not conclusive, as the tests were conducted on only one individual, and they did not take into consideration the chewing habits of that individual. It was established that bilateral chewing did help to stabilize the dentures. This was to be expected. It is unfortunate that tests of pressures in the same areas were not made with closing pressure applied without interposed food. It is thought by many that this is the period of real value of balanced occlusion. Much more work of this nature must be done before conclusions can be drawn safely.

Niels Brill recognizes the need for a special type of prosthesis for use by certain patients including those who are too ill or too old for the usual type of denture service. He calls these restorations hybrid-prostheses because they are not complete or partial dentures in the accepted sense. Retention is obtained by special attachments to the roots of teeth from which the crowns have been removed. The procedure is predicated upon adequate endodontic treatment. The attachment is designed so the minimum strain is

placed on the abutment roots. This makes possible the retention and use of teeth that are too mobile to be used otherwise.

Linden F. Edwards discusses some anatomic facts and fancies relative to the masticatory apparatus. He has reviewed our dental literature and noted the errors we have made in our discussions of anatomy. Some of these errors have been permitted because of the policy of "free speech" in the JOURNAL OF PROSTHETIC DENTISTRY. However, he emphasizes the grave responsibility imposed upon an author for his statements. Loose or careless statements can cause much chagrin when they are brought to light. A basic science, such as anatomy, does not permit the same freedom of belief as do our technical procedures. Study of this article will do much to clarify the thinking of those who may be confused about the facts of anatomy as they relate to our field.

J. Gordon Rubin and Albert A. Sabella describe their technique for making fixed partial dentures which are cast in one piece. They make use of the reversible hydrocolloids for the impressions. The technique eliminates possible errors produced by soldering, which seems to be an advantage. However, it is obvious that other errors could be made unless extreme care and precision are used throughout the procedure.

Russell C. Wheeler discusses the current popularity of the use of full crowns. He is concerned about its excessive use because he recognizes it as "radical" treatment. The dentist who uses it must have an adequate background of knowledge and training in order to use it without danger to the welfare of the patient. This restoration has its place if it is used properly, but it *must* be used properly. Perhaps a little more conservatism would be in order.

Julius Caplan recognizes the need for special care of fixed restorations which have full-coverage abutment restorations. It is obvious that dental caries is more difficult to detect under this type of restoration until it is too late. The procedure for locating caries around these restorations is described. Suggestions are made for preventing cervical caries and for repairing the damage by caries when it is discovered.

—Carl O. Boucher

PATIENT, DENTIST, LABORATORY TECHNICIAN—A COOPERATIVE TRIUMVIRATE

CHASTAIN G. PORTER, D.D.S.*

Kansas City, Mo.

THE CONSTRUCTION AND WEARING of dentures is a cooperative enterprise which may be compared to a tripod or three-legged stool. The three components are the patient, the dentist, and the laboratory technician. If any one of the three is weak or fails to carry his share of the load, the entire structure will be defective, or at least out of balance, although it may serve some limited use. Each of the three participants in denture construction must bear his full share of the responsibility for the best solution of the problem when a human being has lost, or is confronted with the loss of his teeth. The loss of teeth constitutes a serious misfortune which must be faced with fortitude. The solution is deserving of the best effort and methods that can be devised and executed. A satisfactory solution to the problem is not impossible if each participant enters into the project with a spirit of optimism and cooperation. All concerned must profit both materially and spiritually if the outcome is to be truly successful.

THE PATIENT'S RESPONSIBILITY

The patient, who still has natural teeth and realizes that all is not well, must resolve to submit to an oral examination. He must then seek out a reliable and qualified dentist. This may be the family dentist who has striven valiantly to postpone the evil day. Too often, the mouth has been neglected, either without dental care, or with poor or inadequate treatment. In this situation, a new dentist is frequently selected through the recommendation of the physician, friends, casual acquaintances, or even by thumbing through the telephone book. The findings of the new dentist may come as somewhat of a shock, and institute a frantic shopping tour of dental offices to compare opinions. In any event, a decision is reached and a dentist's advice is accepted. This final decision must rest with the patient, and it should not be influenced by high-pressure methods. Only a true and emphatic report of the diagnosis should be given. The patient must become reconciled and willing to undergo the loss of the natural teeth, if necessary, and must understand both the limitations and advantages of complete artificial dentures as compared to his existing dentition in its now deplorable state.

Read before the Walter H. Berry Memorial Meeting of the St. Louis Missouri Dental Society, St. Louis, Mo., April 4, 1955. (A joint meeting of Dentists and Dental Laboratory Technicians.)

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Upon acceptance of the plan of procedure, the patient should place himself in the hands of the attending dentist, and assume an attitude of complete cooperation. Surgical procedures must be instituted which will place the mouth in the best possible physical form. Any necessary medical measures should be taken, as optimal systemic health is very important at this time. The mental health and general morale of the patient is also important, and they are best enhanced by avoiding a toothless state. Immediate artificial dentures can and should be provided in nearly all instances.

The patient must continue to cooperate during the various visits necessary for treatment. A harmonious relationship must be fostered between the patient and the dentist. A good esthetic appearance should be stressed, as this is the most important factor to most patients at this time, and the factor about which they are most dubious. Pre-extraction records are invaluable aids. The patient should help by providing old photographs and expressing himself freely as the construction progresses.

Upon completion and insertion, about all that can be expected of the patient is a steadfast effort to adapt to these strange and foreign objects until they become tolerated, and are welcomed into the stomatognathic system. If the groundwork has been skillfully laid, this should not be too difficult in most instances. Neither the patient nor the dentist should become discouraged or indifferent until success is achieved. The patient should return at intervals for checking, adjusting, or relining, or for new dentures when they are needed in the distant future. He should follow the dentist's instructions and respond to his semiannual recall in order to keep the dentures hygienically clean and the tissues of the mouth in a state of health.

The patient must profit far more than he loses if this procedure is to be rewarding to him. True, he sacrifices much in discomfort, inconvenience, temporary impairment of function, and perhaps in depleted finances. He should profit, however, in better ultimate function, in improved health, and in restored appearance, if he has chosen his dentist wisely.

THE DENTIST'S RESPONSIBILITY

Eberle[1] states, "It is obvious that prostheses of any type are individually unique personal problems and that only by continued study of the components of occlusion, physical phenomenon, physiology, and psychology, may the percentage of failure be kept at a minimum." All phases of prosthesis are the personal responsibility of the dentist, and especially is this true in the mind of the patient. The laboratory is, in turn, responsible to the dentist. This is in the best interest of all concerned. The status quo should and will be maintained. The dentist must qualify as much more than a middleman or sales and delivery person in order to deserve his position, and to justify his financial recompense. Otherwise, he is receiving his reward under false pretense.

Prosthetic service is *not* primarily one of manipulative skill. Dentures should not be regarded as a commodity, but as a therapy. The first duty of the dentist lies in an accurate diagnosis based on radiographic and all other available data,

and leading to eradication of infection, and to the restoration of health to the mouth and associated structures. Sound treatment planning must, then, precede the actual replacement which will restore, not only the lost parts, but also the lost function and appearance. The correct esthetic and phonetic placement of suitably selected and modified teeth on bases harmonious with the anatomy and physiology of the individual patient is of prime importance. Through a study of the complexities of mandibular positioning, movement, and function, a jaw relation which restores lost facial contours is established. The dentist is able to prevent or correct associated cranial or auditory disturbances for many patients. Dentures, especially if inserted immediately after extraction and surgery, are contributory to healing and ideal residual ridge formation. The responsibility for prolonged health and for conservation of the oral and contiguous structures must continue throughout the life of the patient. These factors require a blending of artistic, mechanical, and biologic concepts unsurpassed in any other field of professional endeavor. This is the dentist's over-all responsibility which he could fulfill only with great difficulty without the valued aid and support of the laboratory craft.

How can the dentist meet this responsibility? First, by living up to his most sacred duty—that of good, sound diagnosis and advice to the person in trouble. Needless to say, he shall not be influenced by avarice, nor by the ease or convenience of, or his preference for, doing a certain type of work. Any dentist worthy of his state licensure must be guided by the Golden Rule. Errors of judgment may occasionally be pardoned, but the deliberate removal of teeth for any reason other than the welfare and benefit of the trusting patient is an offense akin to mayhem.

The actual construction entails much painstaking work by the dentist. He must assume personal responsibility for basal coverage as determined by the impressions. He alone has the background for this phase of treatment, by his knowledge of the anatomy, histology, physiology, and variations of the structures involved as they exist in the patient in his chair. He must be the sole judge of the area to cover, the materials to use, the amount of, or avoidance of, tissue displacement, and all other factors involved.

Advice and help from any beneficent source should, perhaps, be welcomed, but it is presumptuous and in poor taste for laboratories or manufacturers to try to teach the dentist how to make impressions. Such advice, whether it be given individually or collectively by courses of instruction, is bound to create some resentment, no matter how well it is intended. Dentists who feel a deficiency in their knowledge should avail themselves of courses which are offered by most of the dental schools, by attendance at dental meetings, by membership in study groups, and by a perusal of the literature, instead of allowing themselves to be influenced by instruction which sometimes has commercial connotations. In defense of such attempts at educating the dentist, it must be said that they are usually motivated by a sincere desire to improve the preparatory work received by the laboratory. Sponsored courses which attempt to bind the dentist to the laboratory, by inducing him to adopt a procedure executed almost entirely by the technician, are particularily obnoxious. In some instances, the dentist performs only minor steps under the supervision and direction of the laboratory. Such methods must be abolished.

The vertical, centric, and any other jaw relation records must, of course, be secured by the dentist. Selection of the type, form, shade, and material of teeth, both anterior and posterior, should be made in the dental office by the dentist. Tooth selection is definitely not an articulator, chart, or measurement operation, and should not be expected of a laboratory worker unless he is possessed of psychic powers and supernatural skills.

The setup or arrangement of teeth for esthetics, function, and ridge preservation is best done by the qualified dentist, but it is often delegated to the technician. On the surface, this appears to be a laboratory phase, but its extreme importance must classify it as the dentist's direct responsibility to the patient. Realizing that this idealistic conception is not too widely practiced, a concession is hereby made by granting that the setup may be done by the one who can do it best. Dentists who have a special flair and interest in prosthesis will find the setup intriguing, enjoyable, and profitable. Those who accept denture work more casually may find it more expedient to delegate this phase of the work, due to their preoccupation with other work, their lack of training, experience, and energy, and due to their personal wishes. In as much as the dentist will receive the final credit or blame by the patient, it is always his duty to give explicit directions, and to make changes at the time of the try-in, both in tooth positioning and in the contour of the facial surfaces of the wax. If this is not done, the results will be most stereotyped, monotonous, and false-looking. Individualized, natural appearance is a factor sadly lacking in many dentures.

Final insertion and occlusal refinement are done by the dentist. This must be followed by good, interested, and cheerful subsequent care, and by patient recall at six-month intervals. If these procedures are well executed, the dentist will merit the respect and confidence of a growing number of patients, and also that of his laboratory co-workers. He will have fulfilled his obligation as a professional man worthy of trust.

THE LABORATORY TECHNICIAN'S RESPONSIBILITY

An older generation of dentists prided itself on its ability to execute all phases of denture construction alone and unaided. The custom is not entirely archaic, as some dentists prefer this practice today. A dentist is a legal entity qualified and licensed to make dentures alone within the walls of his own office and laboratory. Dental students should continue to be thoroughly trained to perform all of the steps in the fabrication of dentures. However, dentists in increasing numbers have found this practice more and more untenable, unsound, and distasteful. In fact, the trend in all health service fields is definitely toward delegation of all possible details to ancillary groups. Just as medical internists do not dispense their own drugs, surgeons do not nurse their patients back to health, and ophthalmologists do not grind lenses, so, most dentists do not process their own dentures. It is outmoded and inexpedient for the busy dentist to bear the entire onus of construction, except in rare instances.

Wright[2] stated, "A technician is an adjunct to the dental profession. He assists the dentist when delegated to do so by fabricating dental appliances ac-

cording to the dentist's prescription." This statement is as true today as when it was written in 1939.

As the foremost adjuvant to the dentist, the laboratory worker should possess or cultivate the same essential qualities of honesty, proficiency, self-examination, and ethics as the dentist. Whereas the dentist's procedure deals largely with intangible factors, the technician's services are concerned principally with tangible objects which meet the eye of both dentist and patient. His job is doubly difficult as he has two critics or censors—the dentist and the patient. His end product should be a thing of beauty conceived and created in a flawless manner. Allen,[3] writing in 1908, stated, "When a work is executed with the concepts of beauty and utility in their proper proportions, that work has its own individual characteristic, the evidence of design. This is its passport, its credential, its hallmark, its justification." A better aphorism could not be framed and hung on the wall of each laboratory and instilled into the hearts of each technician. Such a concept must surely act as an inspiration to all concerned, including the dentist, and reach even to the patient's appreciation, acceptance, and reconciliation to the edentulous state.

The present-day dentist would find it extremely difficult, if not impossible, to execute all of the necessary procedures himself, including the manufacture of teeth and the processing of the dentures. He could not serve so many people; it would be economically unsound; and the quality of the product would suffer from the lack of specialized talent and training. From this situation has arisen the present system of fine, recognized, and accredited or approved laboratories, with good working conditions, and an equitable wage scale for all. The individual possessed of sufficient energy, initiative, and business acumen can, by ownership, build a business more lucrative than is possible for most men in the professional practice of dentistry. Good laboratories, large or small, contribute immeasurably to a high standard of prosthetic health service. There is no valid reason for any subterfuge, discontent, or jealousy between laboratory men and dentists. One vocation is dependent upon the other. In fact, the relationship of the two groups is so intertwined, that it might be called a "symbiosis," a biologic term literally meaning living together.

It is evident that, to preserve and perpetuate this mutually beneficial relationship, there are some things the laboratory worker should do, and some things he should *not* do, nor be asked to do. He should, when requested, receive the dentist's impressions and construct good casts and occlusion rims on well-fitted baseplates. If these impressions, or for that matter, any of the dentist's preparatory work, is not up to a certain standard, he should tactfully inform the dentist of the deficiency. The dentist should not be offended at this action. If the dentist is not willing or capable of providing good foundation work, the laboratory has the choice of either proceeding at the dentist's risk, or regretfully and politely declining to accept the dentist as a patron. This stand may be more economically sound than it might appear at the moment. Perfection cannot be expected in any human endeavor, and working conditions are far from ideal with many patients, but the laboratory should not be made the scapegoat for failure for which it is blameless.

The laboratory should not presume to dictate or even influence the type of tracing device, transfer, or articulator favored by the dentist. If no special appliance is specified, he may exercise his own preference, while the case is in his custody.

The technician should receive the dentist's jaw relation records, and follow explicitly, and to the best of his ability, the dentist's directions as to tooth setting for esthetics and function. In the absence of specific instruction, he should be guided by the arch form and ridge relation, and should provide the best setup possible with the data available. The dentist's recommendation regarding posterior tooth form and occlusal pattern should not be challenged. He should paricularly cherish as a patron, the dentist who sets the teeth himself, and should encourage this practice, or at least not frown upon it.

The laboratory technician should not be chagrined if the setup comes back from the try-in altered by the dentist. Instead, if the dentist lives up to his responsibility, this should be expected and encouraged. It would be a downright miracle if a person, who has had no contact with, or observation of the patient, could provide an arrangement of teeth possessing maximal esthetic appearance.

The final waxing, festooning, and carving may be done by the technician, but the basic contours established by the dentist must be observed. Advice by the laboratory in regard to base materials should be seriously considered. The laboratory has had extensive and varied experience in working and observing all types and kinds of resins, and knows best both their shortcomings and advantages. This advice must be based on known and proved facts, and must not be used as a competitive sales measure without foundation. The laboratory should, however, accept the dentist's decision as to the base material with good grace. Coloring or tinting are within the province of the laboratory. These measures must be varied to meet the judgment, fancy, or even the whim of the dentist and of the patient as interpreted by the dentist. This is a difficult task, and it should be executed with restraint in the absence of specific directions to the contrary. Simulation of natural colors is desirable, but it is definitely not the most important fatcor in esthetics.

Meticulous care should be taken in preserving the denture borders, the occlusion, the jaw relations, and other intangible but invaluable attributes of the dentures as provided for by the painstaking dentist. Technicians are skilled in finishing and polishing, but they can become overzealous and render previous work null and void at this late stage.

Even after delivery of the dentures, the laboratory should cheerfully correct any errors *it* has made. The technician's responsibility should cease at this point and not encompass failures of the dentist. He should not be asked to visit the dental office to make adjustments or to participate in subsequent care. Patients must never be *sent* to the laboratory for repairing, refitting, or lining of dentures. This is illegal as well as unfair, and only of nuisance value to the ethical laboratory. Of course no ethical laboratory would ever jeopardize its reputation by dealing with, or advertising directly to the public, or by doing work for anyone other than a duly licensed dentist.

If the laboratory has perpetuated the denist's delegated work, and has observed these basic tenets, it has well fulfilled its responsibility.

It is exceedingly fortunate that there are many high type, ethical, accredited, and approved laboratories. Dentists and these laboratories working together are providing a high type of health service to the public. There is yet need and room for improvement.

SUMMARY

The misfortune of the loss of the natural dentition can be alleviated by the combined efforts of the patient, the dentist, and the dental laboratory technician. Each must carry his full share of the responsibility without encroaching upon the other's prerogatives. All three participants must labor together compatibly and effectively for the benefit of the ultimate consumer—the patient.

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COMPLETE DENTURE IMPRESSION TECHNIQUE

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A HISTORY OF COMPLETE denture construction is both educational and stimulating. It is interesting to note that many years ago dentists were discussing and advocating varying techniques to overcome the same basic problems that we modern dentists are confronted with today.

George[1] stated in 1869 that plaster was the impression material of choice because it was more plastic than wax or gutta-percha and little pressure was required, thus preventing displacement of the soft tissue parts.

Austin[2] stated in 1866 that plaster impressions of the lower jaw should be taken when ridges are well defined; but when the ridges are absorbed, wax or gutta-percha is preferable.

Franklin[3] described the first corrected impression in 1866. He used wax for the preliminary seat followed by a plaster wash for more accuracy and to prevent expansion of the plaster when used in bulk.

White[4] stated in 1894, "Since the object in taking an impression is to obtain a correct representation of the parts as they are in normal condition, there is needed a substance, plastic at ordinary temperatures, and which will admit of having the parts concerned pressed into it without the use of force enough to cause pain or disturb the relative position and form of the different surfaces. It must also possess sufficient body or hardness to be retained in the tray under the pressure necessary to obtain the impression of the parts. It must harden or solidify in a brief time."

The Green brothers[5] brought out a new impression material, modeling compound, at the turn of the century. Young[6] stated in 1907 that "compound is warmed to a consistency at which it will adapt itself readily to the shape of the mouth. It is placed on a tray and pressed down to get an ordinary impression. It is allowed to stand, and the outside is chilled and pressed down a second time so that the hard ridge cuts just a little deeper into the impression material and remains practically unchanged, while the soft tissues down on the side of the gum, about where the border of the plate comes, are compressed slightly. Thus, the plate margins will be sealed all around, and this converts the lower surface of the plate into a suction pad."

Fish[7] formulated the basic peripheral outline of modern full dentures in an article in 1931.

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Dirksen and his group at the University of Iowa developed a wax which became popular for peripheral extension of impressions in the late 1930's. Swenson,[8] in collaboration with Trapozzano, outlines a technique of impressions using the University of Iowa wax for peripheral extension.

Slack[9] introduced a new plastic impression material called Muco-Seal, and a technique to go with it. It incorporated coverage of the sublingual space for better retention of the lower denture.

Wright,[10] in June, 1948, advocated the use of alginate base impression materials for full denture impression in selected cases.

I should like to mention that the dental profession is indebted to men like Hight,[11] House, Stansbery,[12] Wilson, Tench,[13] Boucher,[14] Pryor,[15] and others, for their contributions to the science and art of full denture impression technique.

ORAL ANATOMY

Upper Peripheral Anatomy.—

1. Maxillary frenum. This is resistant tissue in the midline and must be relieved to its full extent.

2. Labial arches. These are the peripheries on each side of the relieved maxillary frenum which rise in a convex arch form.

3. Buccal frenum. This is movable resistant tissue in the region of the first bicuspid and must be relieved to its full extent (Fig. 1).

4. Zygomatic process. The denture border dips in this region (approximately in the second bicuspid and first molar zone) to avoid impingement upon this resistant bone.

5. Buccal vestibule. The border in this region is most important for retention. The space between the ridge and the cheek must be filled to its full height and width.

6. Vibrating line. This is the junction of movable and nonmovable portions of the palate, and forms the posterior limits of the denture (Fig. 2).

7. Pterygomaxillary notch. This is the first cleft posterior to the maxillary tuberosity enabling the denture to be sealed laterally into the soft tissue (Fig. 2).

Upper Surface Anatomy.—

1. Incisive papilla. This raised bit of soft tissue on the ridge posterior to the position of the junction of the central incisors must be relieved to prevent pressure on the nasopalatine nerves and the blood vessels. Failure to relieve the incisive papilla may cause a burning sensation in the palate (Fig. 1).

2. Torus palatinus. This bony mass in the midline should be relieved if it is present. If not, a relief in this area is not indicated (Fig. 1).

Lower Peripheral Anatomy.—

1. Mandibular labial frenum. This is usually resistant and must be relieved.

2. Labial arches. The denture border is convex on either side of the mandibular labial frenum (Fig. 3).

3. Mandibular buccal frenum. This resistant and movable tissue is to be relieved to its full extent (Fig. 3).

4. Buccal shelf. This is a convex arc from the buccal frenum to the anterior portion of the retromolar pad, bounded laterally by the external oblique line and medially by the residual ridge. The bone structure of the buccal shelf is very dense and presents an excellent bearing area (Fig. 4).

5. Distobuccal corner. This region, buccal to the retromolar pad, is governed by the inward pull of the masseter muscle. It swings sharply toward the lingual (Fig. 5).

Fig. 1.

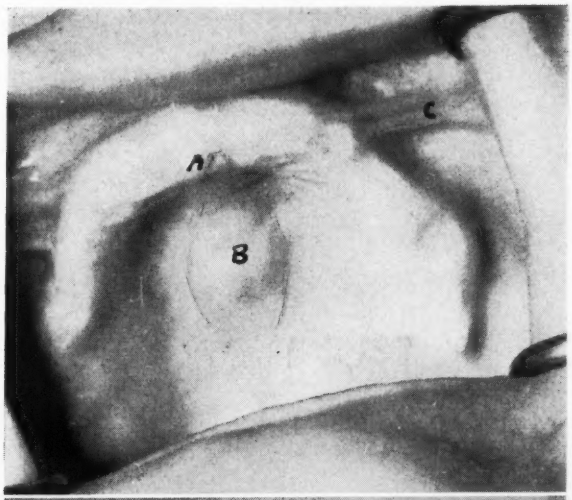

Fig. 2.

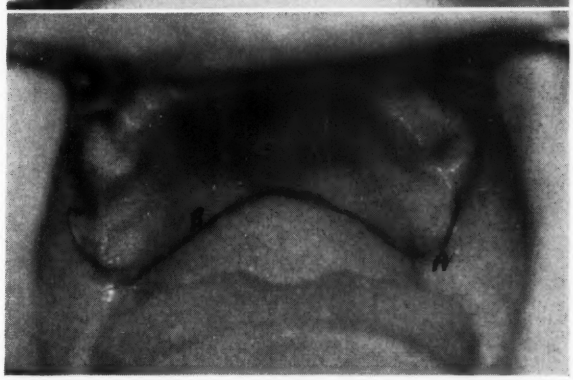

Fig. 1.—Landmarks in the upper jaw. *A*, Anterior palatine (incisive) papilla. *B*, Torus palatinus. *C*, Buccal frenum with the caninus muscle.
Fig. 2.—Posterior landmarks. *A*, Pterygomaxillary notch. *B*, Vibrating line.

6. Posterior border. The distal border of the retromolar pad is the posterior termination of the lower denture.

7. Distolingual turn. This region is governed by the extent of movement of the palatoglossus muscle and the superior constrictor muscle of the pharynx. It is convex, and its posterior termination is even with the posterior termination of the retromolar pad (Fig. 5).

Fig. 3.

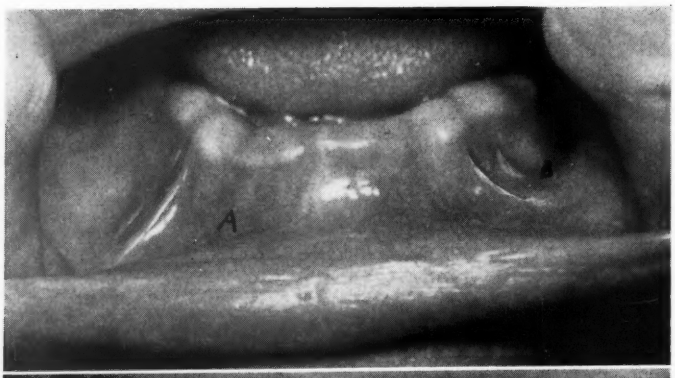

Fig. 4.

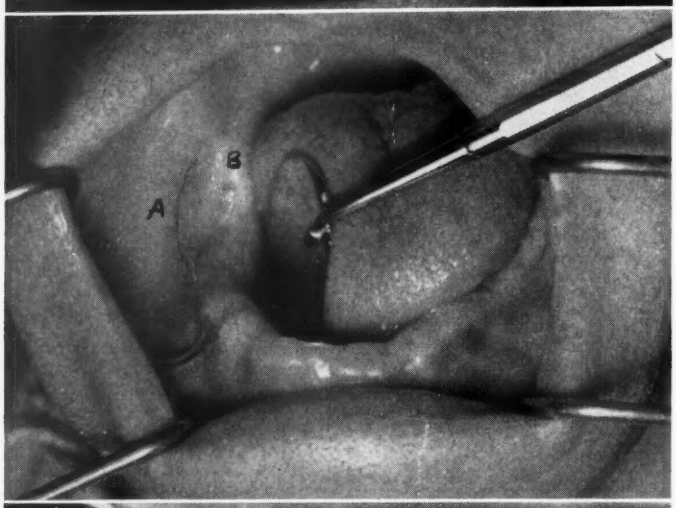

Fig. 5.

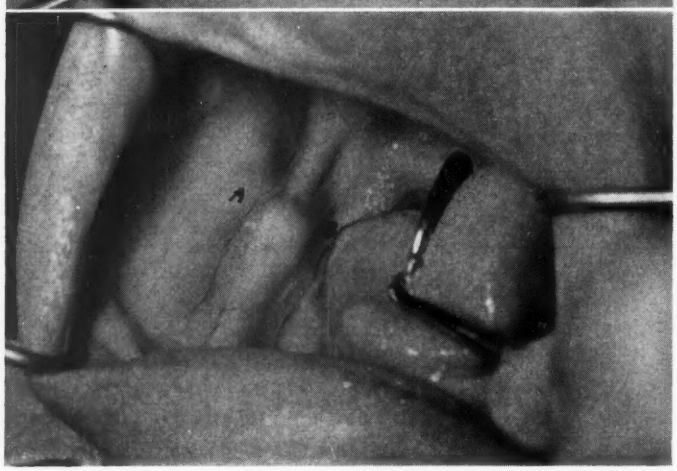

Fig. 3.—The lower jaw. *A*, Mandibular labial arch. *B*, Mandibular buccal frenum with the triangularis muscle.

Fig. 4.—Posterior landmarks. *A*, Buccal shelf. *B*, Retromolar pad.

Fig. 5.—Distal landmarks. *A*, Distobuccal corner. *B*, Distolingual turn.

8. Middle lingual. The flange usually extends below the mylohyoid ridge and is governed by the extent of movement of the mylohyoid muscle as the tongue is moved into the cheek of the opposite side.

9. Sublingual flange. The flange, lingual to the anterior portion of the ridge, is extended to cover the tissue to varying degrees, depending on the position and type of mandibular lingual frenum and the position of the orifices of the submaxillary ducts.

a. If the lingual frenum is broad and close to the crest of the ridge, the sublingual flange will cover the frenum only for the usual lingual muscle trim, but the space on either side of the frenum will be covered approximately ⅛ inch beyond the normal mucolingual turn.

b. If the lingual frenum is narrow and close to the crest of the ridge, the frenum is allowed freedom of movement in the impression, but the area on either side is covered ⅛ inch beyond the usual mucolingual turn.

c. If the lingual frenum is posterior to the ridge, the tissue is covered ⅛ inch beyond the mucolingual turn.

Lower Surface Anatomy.—

1. Torus mandibularis. This nodule (or nodules) of bone on the lingual side of the ridge in the first or second bicuspid region has a thin covering of soft tissue.

EXAMINATION AND HISTORY OF PATIENT

Radiographic Examination.—

1. Note retained roots and cysts.
2. Note the texture of the supporting bone.

Clinical Examination.—Observe the following conditions if they exist:

1. Undercut bony areas along the ridge.
2. Undercut, bulbous, and low-hanging tuberosities.
3. The size and extent of the torus palatinus and torus mandibularis.
4. The type of saliva. Thin saliva does not seal a denture well. Thick ropy saliva is annoying to the patient.
5. The type of ridge, knife-edged, flat, full and bulging, or soft due to the absorption of bone.
6. The type of soft tissue. Note the lack of resiliency, excessive resiliency or normal resiliency of the soft tissues.
7. The tongue size.
8. The muscle attachments.
9. The lip length.
10. The sublingual space. The position and size of the mandibular lingual frenum and the location of the ducts of the submaxillary and sublingual glands are important diagnostic facts.
11. The retromylohyoid space. This is the space lingual to the retromolar pad. Occasionally, this space is eliminated when the tongue moves forward or upward, thus preventing the formation of a lingual flange in this region. The efficiency of such a denture is reduced.

Medical History.—This should include the following pertinent facts:

1. A record of any current illness.
2. A record of any past illness.
3. A record of a typical diet.

It is necessary to realize the importance of the proper preparation of the edentulous mouth to avoid serious difficulties in the construction of complete dentures. Many times, a simple surgical procedure spells the difference between success or failure. The examination is also important in preparing the patient for any possible esthetic disadvantage. We should at all times evaluate the clinical, radiographic, and medical history evidence. The reason why certain procedures are necessary should be explained to the patient, together with the limitations of the case. I have found that mounted study casts are extremely useful to me in making my diagnosis, treatment plan, and prognosis. I highly recommend their usage because a patient is better able to comprehend what we are explaining to him.

IMPRESSION TECHNIQUE

The Preliminary Compound Upper Impression.—

1. *The type of tray:* The aluminum tray should be thin, stiff, and easily modified with pliers, scissors, or fingers.

2. *The tray size:* The tray is inserted and first seated posteriorly and then anteriorly so that, when the tuberosities are covered, the anterior ridge of the patient fits into the anterior ridge indentation of the tray.

The objectives of the proper tray selection are to use the tray as a convenient carrier of compound which will not interfere with muscular movements when the impression is being made and to localize the compound mass over the bearing areas.

3. *The stacking of compound:*

a. Two cakes of Kerr's medium-fusing compound are softened in the compound heater with the temperature of the water at 160° F.

b. The compound is kneaded carefully to prevent the trapping of air and then is placed on the tray.

c. The compound is sculptured to the approximate shape of the ridges and vault.

d. The compound is luted to the tray by pin-pointing the flame from a Hanau torch at the junction of the tray and the compound.

The objective of proper compound stacking is to prevent the compound from breaking away from the tray during the impression making.

4. *The initial insertion:*

a. The compound is dried and a flame from a Hanau torch is played over it.

b. The compound is placed in warm water in a water heater for tempering.

c. The compound tray is inserted into the mouth, the patient is told to close the mouth, and then the tray is seated with firm but light pressure.

d. The impression is removed carefully without chilling (Fig. 6).

The objective of the initial insertion is to divide the bulk of compound evenly so that the impression can be worked out without the compound being penetrated or the tray off-centered. The patient is told to close slightly before the seating to prevent muscular interference from the cheeks and lips.

5. *The beading of the compound:*

a. The borders of the impression are squared by knife-trimming.

b. A groove is cut into the median line to a depth of approximately 1 mm.

c. The flame from a Hanau torch is played on the surface of the dried compound, care being taken not to collapse the flanges.

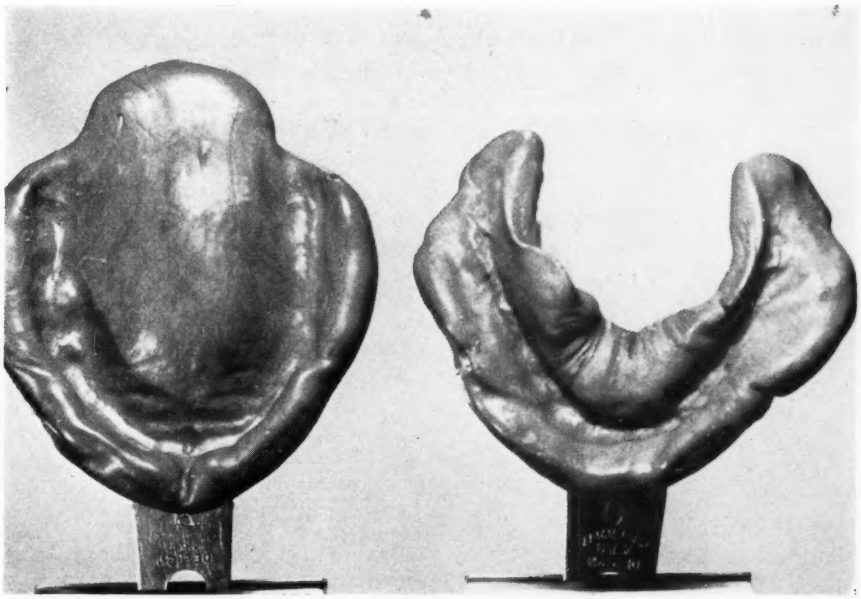

Fig. 6.—Preliminary impressions after the initial seating.

d. The compound is tempered in the water bath.

e. The compound tray is then inserted into the patient's mouth and seated with firm pressure exerted by the index finger at the center of the palate.

f. The patient's nose is held, and the patient is told to breathe out through the nose while the pressure is being exerted on the palate.

g. The compound impression is removed carefully without chilling (Fig. 7).

The objective of the beading of the compound is to obtain a deeper seating with as little overdisplacement as compound permits. The warm compound can flow toward the knife mark or out over the borders, thus reducing the flowing time and the distance of flow. Breathing through the nose will cause the movable palate to press downward against the surface compound for good detail.

This step completes the treatment of the basal seat area. The groove is usually completely filled, and there is a bead of compound around the entire border. If the groove is not completely filled, it can be filled with carding wax upon the com-

pletion of the impression. At this point we are assured that the compound has flowed properly, and that we have minimized any overdisplacement of tissue.

6. *The border trim:*

a. *The posterior or buccal border.*

(1) The flanges of the impression are knife-trimmed 2 mm. below the outline of the mucobuccal fold.

(2) Green stick compound is added to the posterior section of one buccal flange by heating the stick of compound in the flame, and dropping it on the border compound. The flame from the Hanau torch is then applied carefully to the green compound which is tempered in the water bath, and the impression is inserted into the mouth. The patient is told to close before the impression is seated completely.

(3) The tray is held with a light pressure, and the patient is told to open and close, to swing the mandible from side to side, and to force the cheek inward.

(4) These procedures are repeated on the opposite side.

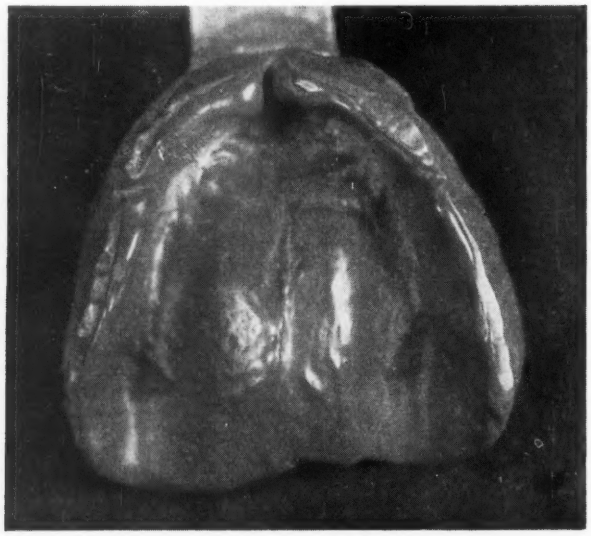

Fig. 7.—The compound is beaded along the borders.

The buccal vestibules opposite the maxillary tuberosities are opened when the patient closes, so that the compound can flow upward to seal this important border region. When the patient opens, the coronoid processes of the mandible press against these borders to establish their correct width. The other functional movements will trim the border for proper height and width. The side-to-side movement of the mandible will cause the coronoid process to press against the lateral surface of the compound for proper external form.

b. *The anterior or facial border.*

(1) Green stick compound is added to the anterior flange.

(2) Upon insertion of the compound, the patient is told to pull the lip downward as in sucking on a straw, and then to grin broadly.

These facial movements will allow the orbicularis oris muscle to muscle-trim the anterior flange.

7. *The fire-polishing of the compound:* The impression is dried thoroughly. A brush flame from the Hanau torch is played lightly over the entire surface of the compound. The compound is tempered in warm water and then inserted with firm pressure. The patient is told to suck, grin, and move the mandible from side to side. This step will give greater detail and smooth out any minor defects in the compound. The impression is now chilled and removed carefully.

The Compound Preliminary Lower Impression.—

1. *The type of tray:* The aluminum tray should be thin and stiff and capable of being easily modified with pliers, scissors, or fingers.

2. *The tray size:* The tray is inserted and seated anteriorly first and then brought down posteriorly. When the anterior ridge of the mouth fits into the ridge of the tray, the posterior borders of the tray must coincide with the posterior limits of the retromolar pads.

3. *The tray modifications:* The posterior portions of the tray are tilted upward. The sublingual section is tilted upward. The lateral surfaces of the tray are trimmed (if necessary) just short of the mucobuccal fold. The labial border must be short of the mucobuccal fold.

A proper fitting tray is used mainly as a convenient carrier of compound and to localize the mass of softened compound over the bearing areas. The tray is trimmed to prevent impinging on the soft displaceable peripheral tissues during the impression making. The posterior sections are tilted upward to allow for the rise of the mandible and thus to maintain a similar amount of compound anteriorly and posteriorly.

4. *The stacking of the compound:*

a. Two cakes of Kerr's medium-fusing compound are placed in the heater with the temperature of the water at 160° F.

b. The compound is kneaded carefully, rolled into a cylindrical form, and stacked on the tray.

c. The compound is luted to the tray by pin-pointing the flame from the torch at the junction of the tray and the compound.

5. *The initial insertion:*

a. The compound is dried, and the flame from an alcohol torch is played over the surface of the compound.

b. The tray is placed in the water bath for tempering the compound.

c. The tray is inserted into the mouth and seated with light pressure.

d. The impression is removed carefully without chilling (see Fig. 6). The initial impression must extend to cover the entire retromolar pad.

The objective of the initial insertion is to divide the bulk of compound evenly from front to back and side to side, and to center the tray in the mouth.

6. *The beading of the compound:*

a. A groove 1 mm. deep is cut into the compound along the groove made by the crest of the ridge (Fig. 8).

b. The flame from the torch is played on the surface of the dried compound, care being taken not to collapse the flanges.

c. The compound is tempered in the water bath.

d. The compound tray is inserted into the patient's mouth with firm pressure; the index finger of each hand is held over the second bicuspid-first molar area.

e. The compound tray is removed carefully without chilling.

The objective of the compound beading is to obtain a deeper seating of the impression with as little overdisplacement as compound permits. The warm compound can flow toward the knife mark or out over the periphery; thus the flowing time and the distance of flow are reduced. This step completes the treatment of the basal seat.

7. *The border trim:*

a. *The posterior buccal border.*

The distobuccal corner of the left side is flamed with the dry heat from the alcohol torch, and then tempered in the water bath. The buccal border opposite the retromolar pad is trimmed by the patient's closing while the impression is held in place with a pressure exerted downward to counteract the closing. This will activate the masseter muscles to mold the distobuccal corner of the impression.

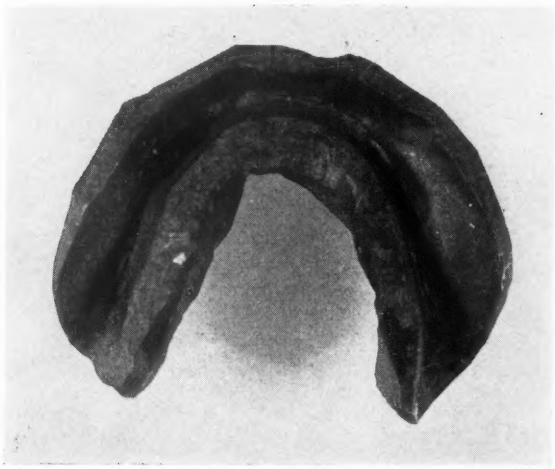

Fig. 8.—A groove is cut in the bottom of the groove made by the crest of the ridge, and the borders are prepared for beading.

b. *The middle buccal border.*

The buccal shelf portion of the border, between the retromolar pad and the buccal frenum, extends laterally to the external oblique ridge. This area of the compound impression is flamed, tempered, and the impression is inserted. (If the compound impression does not extend to the external oblique ridge, green stick compound is added.) The patient is told to draw the cheek inward while the impression is held in position.

c. *The labial arches.*

Green stick compound is added to the labial arches. This compound is then flamed and tempered in the water bath and inserted in the patient's mouth. The patient is told to draw the lips inward, as if sucking on a straw, to mold this anterior flange border.

d. *The lingual border.*

The posterior lingual border is knife-cut until it is level with the mylohyoid ridge. If this flange is short of the mylohyoid ridge, green stick compound is added, flamed, tempered in the water bath, and the impression is inserted in the patient's mouth. The impression is removed and chilled. The green stick compound is then cut level with the mylohyoid ridge. The inner surface of the cut lingual border is shaved to allow for a thickness of wax. The compound is shaved on the inner surface of the lingual flange almost up to the crest of the ridge (Fig. 8).

Fig. 9.

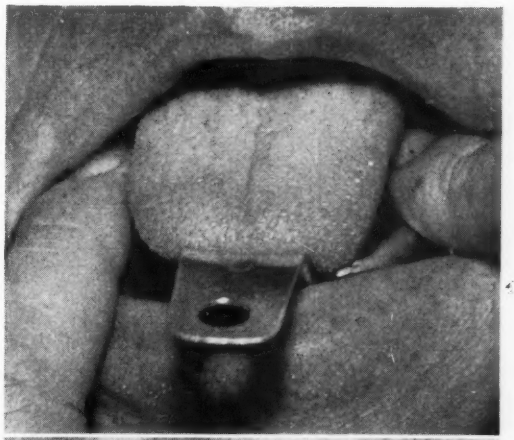

Fig. 10.

Fig. 9.—A tongue movement for trimming the wax on the lingual flange.
Fig. 10.—Another tongue movement for trimming the wax on the lingual flange.

e. *The sublingual space.*

The sublingual space or the space lingual to the mucolingual fold between the location of the first or second bicuspid, from one side to the other, is knife-shaved approximately 2 mm. The compound is shaved to the impression of the crest of the ridge without cutting away the distal extension of the compound.

The compound of the retromolar pad area is shaved to allow for a thickness of wax.

f. *The wax lingual trim.*

(1) A stick of Kerr's low-fusing impression wax (University of Iowa Form-

ula) is softened in a flame or in the water bath. After the impression and the wax have been dried thoroughly, the wax is luted to the cut lingual flange with a hot wax spatula.

(2) The region of the retromolar pad in the compound is coated with the same wax.

(3) The sublingual space is coated with the wax to a thickness of approximately 2 mm.

(4) The entire impression is then immersed for a few seconds in the water bath with the temperature at 140° F.

(5) The impression is inserted into the patient's mouth and held in position three minutes. The tray is inserted further back with the distal ends higher than usual, and then brought downward and forward.

(6) The patient is told to move the tongue from side to side; up to the roof of the mouth and straight out of the mouth (Figs. 9 and 10).

(7) The impression is chilled thoroughly with ice water while the patient holds the tongue partly outside the mouth.

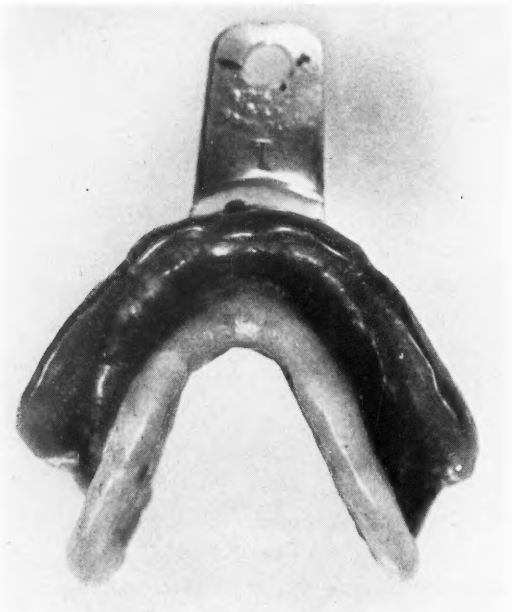

Fig. 11.—The completed mandibular preliminary impression.

(8) The impression is removed carefully by being lifted upward and posteriorly, and then outward (Fig. 11).

The sublingual space is covered, as much as muscle movement permits, for greater retention of the mandibular denture. The tongue rests upon the lingual flange, and this action tends to hold the denture in position. Coverage of the sublingual space also permits the mandibular denture to rest on soft tissues, which is desirable. The wax lingual trim will record a correct lingual roll and will also prevent displacement of the soft tissues of the retromolar pads.

LABORATORY PROCEDURE

The upper impression is boxed and a stone cast is constructed. A double-thickness shellac baseplate is adapted to the upper cast. A short handle is made from a tongue depressor, and this is embedded into the baseplate (Fig. 12). The lower impression cannot be boxed because of the lingual wax trim, so extra care

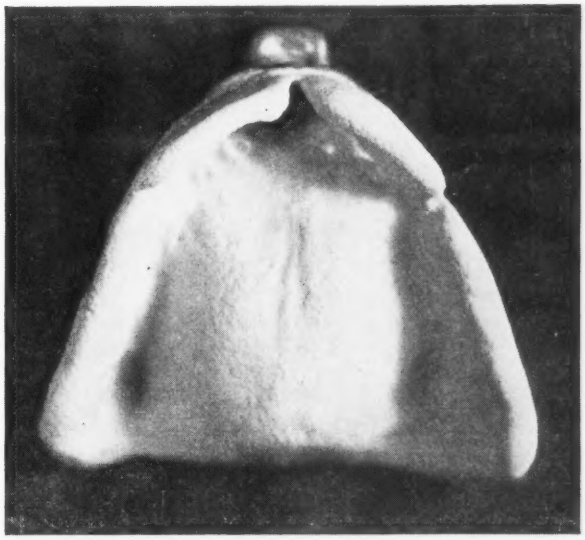

Fig. 12.—The double thickness shellac base tray used for making the final maxillary impression.

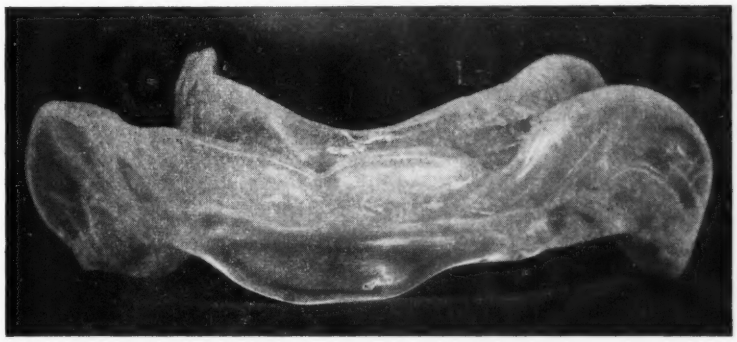

Fig. 13.—The clear acrylic resin tray used for making the final mandibular impression.

must be used in making the stone cast. A thin mix of the stone is vibrated into the impression. As soon as the surfaces are coated, a heavier mix is vibrated into the impression until it is entirely filled. A mass of the stone with a puttylike consistency is placed on a glass slab, and the impression is carefully jiggled into it. The buccal and lingual borders must be embedded in the stone. After the initial set, the stone is trimmed carefully to preserve the border roll.

A clear acrylic resin tray, with a short handle, is processed for making the lower final impression tray (Fig. 13).

THE FINAL IMPRESSIONS

Upper Final Impression.—The shellac tray is inserted in the patient's mouth in order to check its borders with the peripheral tissues. The maxillary frenum and the buccal frenula are relieved if there is any impingement. If this is not done correctly, the muscle roll of the borders cannot be recorded with the final zinc oxide and eugenol paste impression. The relief of these areas can be made with a safe-side Carborundum disc, a bur or vulcanite file.

The area of the zygomatic process is carefully observed to make sure that the tray does not impinge on this resistant tissue. A clinical observation is made by holding the tray in the hand and noticing if this area bulges outward from the remainder of the border. The border is usually at right angles to the line of sight, and an impingement on the zygomatic process is evident by an outward bulge in this area.

The labial arches must be filled to their correct height and width. As explained previously, the coronoid portion of the mandible constricts the buccal vestibule opposite the tuberosity when the mouth is opened.

To test the tray height for this region, it is necessary for the patient to close the mouth after insertion and to run the index finger over the border. If there is an underextension, a space is felt. In this situation, low-fusing compound is added to this flange, and the desired height is obtained by asking the patient to close and open the mouth.

The labial arches on either side of the maxillary labial frenum are then tested for height and width. Underextension can usually be detected by running a finger along the border of the tray, and feeling a space between the tray and the mucobuccal fold. Overextension can usually be observed by the facial appearance of the patient with the mouth closed. Any undue tension on the tissues in this region of the mouth must be corrected before proceeding. It must be clearly understood that tension can be caused by underextension, as well as overextension.

The posterior limitations of the tray must extend beyond the pterygomaxillary notch on each side, and also beyond the vibrating line.

The check for the proper posterior extension of the final impression tray is done as follows:

1. The posterior edge of the dry tray is marked with indelible pencil.
2. This mark is transferred to the tissues by insertion of the tray in the mouth.
3. The tissues distal to the tuberosities are palpated with a T-shaped burnisher to observe the distal extension marks of the tray in relation to the position of the pterygomaxillary notch.
4. The patient is asked to say "ah." This will cause the vibrating line to become visible. The vibrating line, or the junction of the movable and nonmovable palate, must be within the confines of the tray.

Four holes are now drilled in the palate of the tray with a 557 crosscut fissure bur. These holes will permit the impression paste to flow through and avoid the

trapping of any air on the surface of the impression; also, the tray will be seated with a minimum of pressure being created inside it.

The patient's palate is swabbed with cotton on an applicator, and the patient is told to gargle with a solution of water and essence of caroid. This mixture is made by adding one-half teaspoonful of essence of caroid to a glass of water. The caroid will impede the formation of mucus on the palate which would cause the undesirable pitting of the impression. The patient's lips are coated with petroleum jelly.

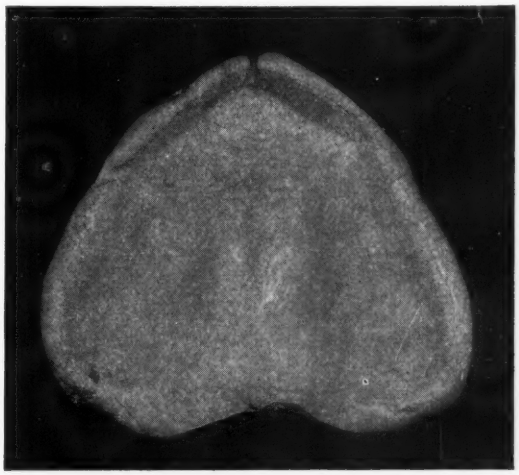

Fig. 14.—The final maxillary impression.

A zinc oxide and eugenol impression paste is used for the final impression. The proper proportions are mixed on a glass slab, and after thorough spatulation, the mix is placed inside the shellac tray. The tray is inserted in the patient's mouth by placing the posterior part in contact with the tissues first and then bringing the anterior part into contact. The tray is seated without undue pressure, and then held by the index finger in the center of the palate. The patient is told to close and open the mouth; to swing the mandible from side to side; to draw the lips and cheeks inward; to contour the lips as in smiling. After three minutes, the impression is removed (Fig. 14).

The reasons I use a zinc oxide and eugenol impression paste for the final impression are: (1) It flows very easily. (2) It remains plastic long enough to allow the peripheral tissues to function for a detailed peripheral roll. (3) It eliminates any premature tissue contact acquired by the compound. (4) No separating medium is required. (5) The impression can be reinserted for testing. (6) It is not unpleasant or harmful to the patient. (7) It does not change form when set.

Lower Final Impression.—The clear acrylic resin tray is inserted into the patient's mouth and tested for retention. The patient is told to move the tongue outward, to each check, and to the palate. The tray should not be dislodged by any of these movements.

The stability of the tray is then tested. The forefinger is placed in the region of the second bicuspid of the left side and an attempt is made to tip the tray; the same test is made on the right side. Placing the forefinger over the anterior ridge and exerting downward pressure will tend to tip up the posterior portion of the tray. The tray should not be dislodged by any of these movements if it is stable.

The tray is then tested for overdisplacement of the tissues. Blanched tissue, indicating overdisplacement, can be observed through the clear acrylic resin tray. This can be relieved by grinding with a stone or vulcanite bur.

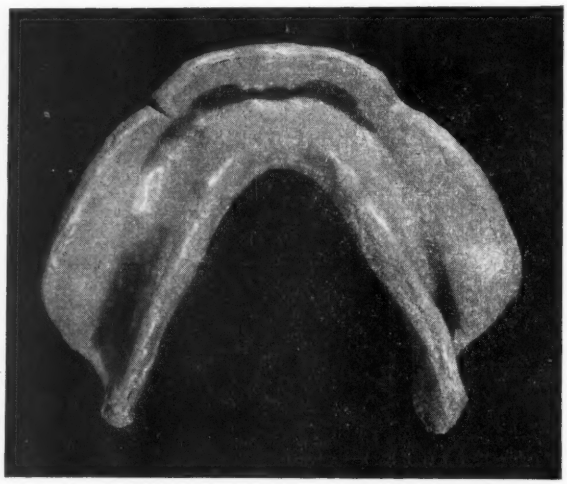

Fig. 15.—The final mandibular impression.

The mandibular labial frenum and the buccal frenula are checked to make certain that they are relieved sufficiently.

The tray is removed from the mouth and dried thoroughly. Petroleum jelly is applied to the lips and chin, and the patient is told to rinse the mouth with the solution of essence of caroid and water.

The zinc oxide and eugenol impression paste material is placed inside the tray and over the borders. The tray is seated with light but positive pressure. The patient is told to move the lower lip upward and inward as if drawing on a straw, and to draw the cheeks inward. When the impression material can be indented by fingernail pressure (while still holding the impression in position) the patient is told to move the tongue outward, side to side, and to the roof of the mouth. This step must be done very carefully because, if the impression material is allowed to harden too much, it will be impossible to record the border of the lingual flange accurately. Likewise, if the paste is too plastic, the lingual border will not be accurate because the structures in the floor of the mouth will squeeze the paste lingually. The impression paste must be just firm enough to offer resistance to the movements of the muscles in the floor of the mouth to form an accurate border roll. The final mandibular impression is removed after the impression material has set (Fig. 15).

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ARTICULATOR MOUNTING BY FUNCTIONAL MAXILLOMANDIBULAR RECORDS

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PROMINENT AMONG THE many controversial issues in articulation, is one involving contentions pro and con on "strained" and "unstrained" jaw relationships. There seems to be no middle ground in this argument. Proponents of strained relationships argue vehemently that it is impossible to retrude the jaw too far when manual force is used against the chin. The opposition advances contradictory opinions with equal fervor.

The faction having by far the greater number of adherents favors the "unstrained" concept. In making maxillomandibular records for the purpose of mounting casts or occlusion rims in the articulator, this group is careful to avoid any force against the patient's chin as he closes. This is based upon the belief that force exerted by the operator against the jaw will create a "conditioned movement"[1] resulting in an unnatural jaw position; one that will not be correct or suitable in function.

Such a contention must depend for its validity upon the elasticity of the involved muscles and ligaments, the compressibility and viscosity of the joint tissues, and the flexibility of the bones of the mandible and cranium. If muscles and ligaments are grossly extensible during contraction of the muscles, if joint tissues are compressible and/or displaceable, and bones are flexible, the advocates of the unstrained concept would seem to have the better of the argument. But, if none of the involved muscles, ligaments, avascular tissues or bones are subject to appreciable distortion by strains while in function, the opposite would appear to be true.

Simple observation and deduction tend to cast doubt upon the theory that jaw mechanisms can be distorted and improperly positioned by external forces while functioning. They are, by nature, capable of handling external loads or forces efficiently. If normal muscles were handicapped by an indefinite extensible limit, how could any animal, including man, engage in efficient work or lift heavy loads? If normal ligaments gave and normal joint tissues compressed and/or displaced to any appreciable degree, how could positive, vigorous, and *accurate* physical action take place?

MANDIBULAR MUSCULATURE

The anatomy and physiology of the jaw also tend to refute the distortion or "conditioned movement" theory. The only muscles of the jaw that could possibly be affected by the operator's effort to retrude the jaw artificially are the external

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pterygoids. But, the external pterygoids play no part in closing function—the movement that is important in occlusion. They are employed exclusively as the unilateral or bilateral protrusive elements in jaw *opening*. During the final power closure, they are relaxed while the masseter, internal pterygoid, and the anterior fibers of the temporal muscles move the mandible along a combined medial, vertical, and protrusive arc. Consequently, it would appear that the external pterygoid muscles may be discounted and their functional action in protruding the jaw may, with safety, be artificially and forcibly eliminated in making maxillomandibular records. In fact, it appears to be *necessary* to do so.

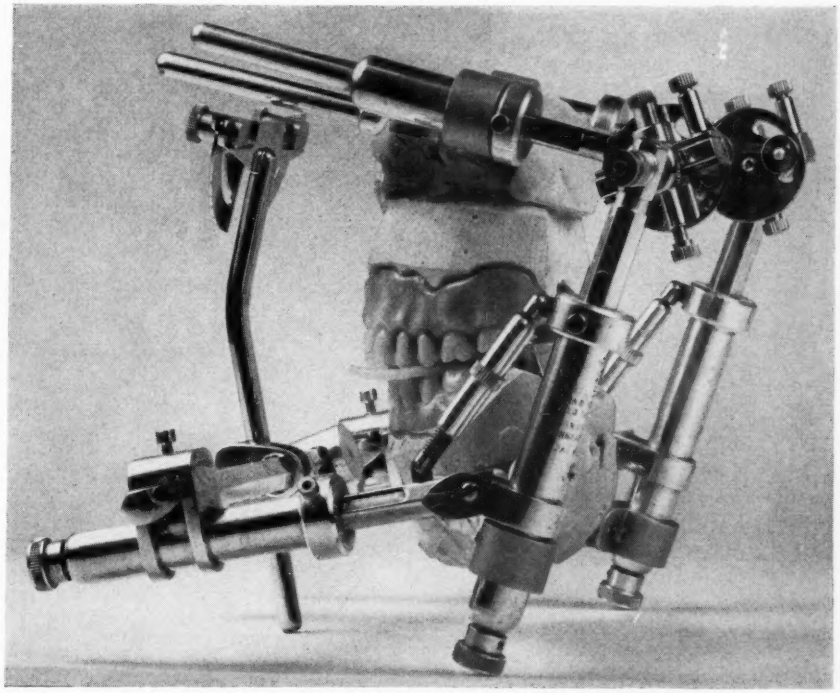

Fig. 1.—Dentures mounted in a Transograph with a 3 mm. hinge maxillomandibular record in place.

Anyone with ordinary experience in taking "hinge bites" can testify that one or both external pterygoid muscles may be expected to be most annoyingly active. It seems to be that the patient has a natural impulse to thrust the mandible forward whenever a *voluntary* "bite" is requested. Dental literature is replete with comments on this tendency, and with ingenious ways to overcome it. Diagrams of the initial opening stroke by Posselt[2] and Beyron[3] show that a protrusion always precedes the opening of the jaws. A patient left to his own devices will consistently deliver a maxillomandibular record that is grossly anterior to his normal jaw relationships. Therefore, it seems to be not so much a question of creating a "conditioned movement" or a possible jaw malposition as of counteracting an abnormal protrusion. It is not uncommon to find that an elderly and apparently fragile woman can deliver a protrusive and abnormal maxillomandibular record in

spite of all efforts exerted by a husky male dentist to retrude her jaw to its correct hinge position.

Of course, it is possible to train a patient until he can deliver a correct maxillomandibular record with the jaw in hinge position. However, the effort is much greater, and the time spent in training is longer than when making a maxillomandibular record wherein the patient is ordered to relax his jaw muscles and close, while the operator exerts manual force against the point of the chin. Even when a patient has been trained to retrude and close, the record is frequently incorrect.

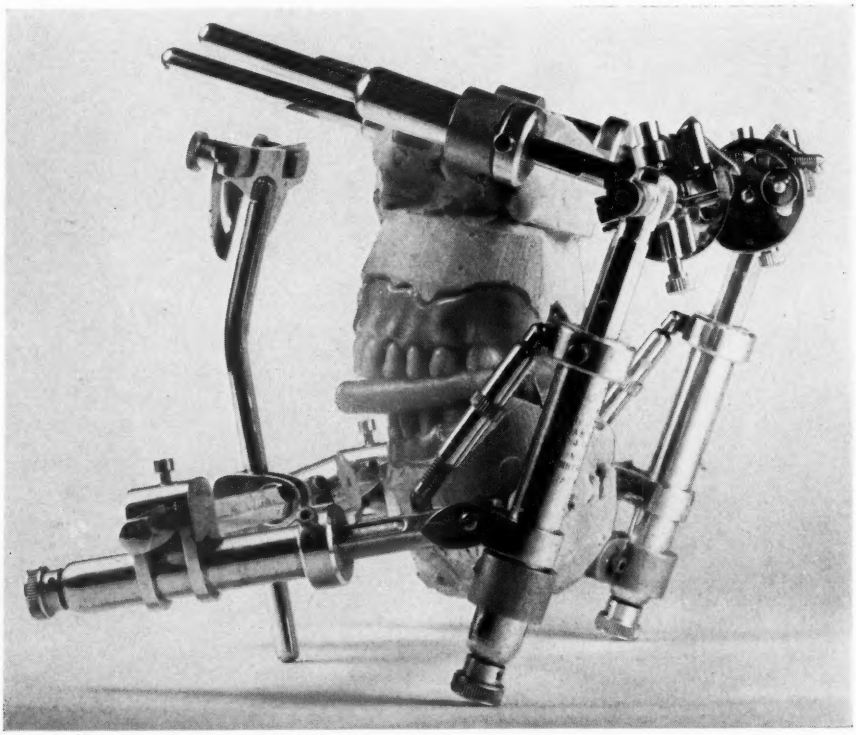

Fig. 2.—The same mounting with a 10 mm. hinge maxillomandibular record in place. Note that the teeth fit into it perfectly.

When a patient retrudes his jaw voluntarily, and closes, the predominant forces come from the temporalis muscle. Its posterior fibers retract the condyles while the central and anterior fibers elevate the body of the mandible. The result is usually a slight opening at the posterior and a compensating overclosure at the anterior part of the mandible. To avoid this anomaly, it is necessary that the operator exert a slight *downward* as well as a heavy retrusive force against the patient's chin. The downward force requires the patient to use his masseter and internal pterygoid muscles in order to close the jaw. This corrects the posterior opening and closes the jaw on the same arc of closure that would be followed by the patient in normal function.[4]

THE TEMPOROMANDIBULAR LIGAMENTS AND THE HINGE POSITION

Once the external pterygoid muscles are eliminated from action in the closing movement, the limiting action of the temporomandibular ligaments can come into play. These ligaments are extremely tough. They originate in the roots of the zygomatic arches, and extend downward and backward at an approximate 45 degree angle to insert laterally and posteriorly at the necks of the condyles. As the posterior fibers of the temporal muscles retrude the condyles in normal function where the main closing muscles are also part of the synergy, the temporomandibular

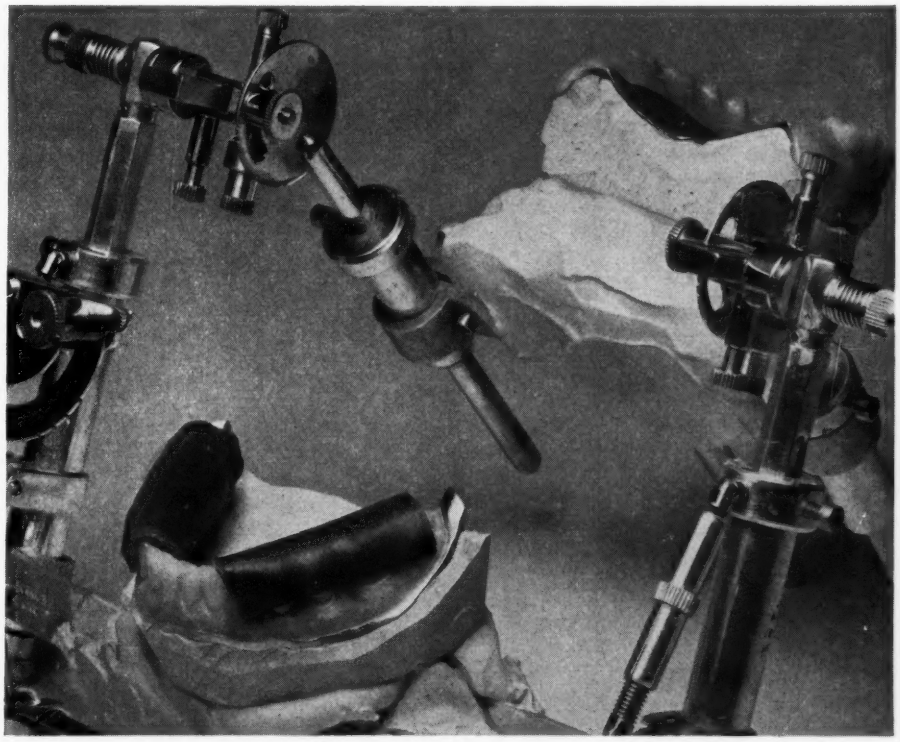

Fig. 3.—Four layers of a tacky wax placed on the occlusal surfaces of the lower teeth preparatory to making a chew-in record.

ligaments arc the condyles upward, and sometimes fractionally forward, into their correct hinge or fulcral positions against the anterior slopes of the mandibular fossae. When the operator forces the jaw back until the resistance of the external pterygoid muscles has been overcome, this is the exact situation that results. The condyle position attained is identical with the condyle position attained by the patient in a natural or power closure. This need not be argued as a theory incapable of substantiation; it is now readily provable that manual retrusion of a jaw to hinge position coincides exactly with the normal *functional* hinge position of the jaw.

TESTS OF THE RECORDS

Let us assume that we have an edentulous patient who has dentures that have been fabricated to relationships established by a manual retrusion of the mandible—a so-called "strained" relationship. The teeth have been arranged on a Transograph and have been pronounced correct both for simple hinge occlusion and for functional occlusion. The means by which such proof is established has been described elsewhere.[5]

Fig. 1 shows the Transograph accepting a maxillomandibular record made with the mandible brought to hinge position forcibly. Note that this record creates an occlusal separation of about 3 mm. Fig. 2 shows the Transograph likewise accepting a similarly executed static maxillomandibular record where the occlusal separation is about 10 mm. The fact that the Transograph copies the jaw

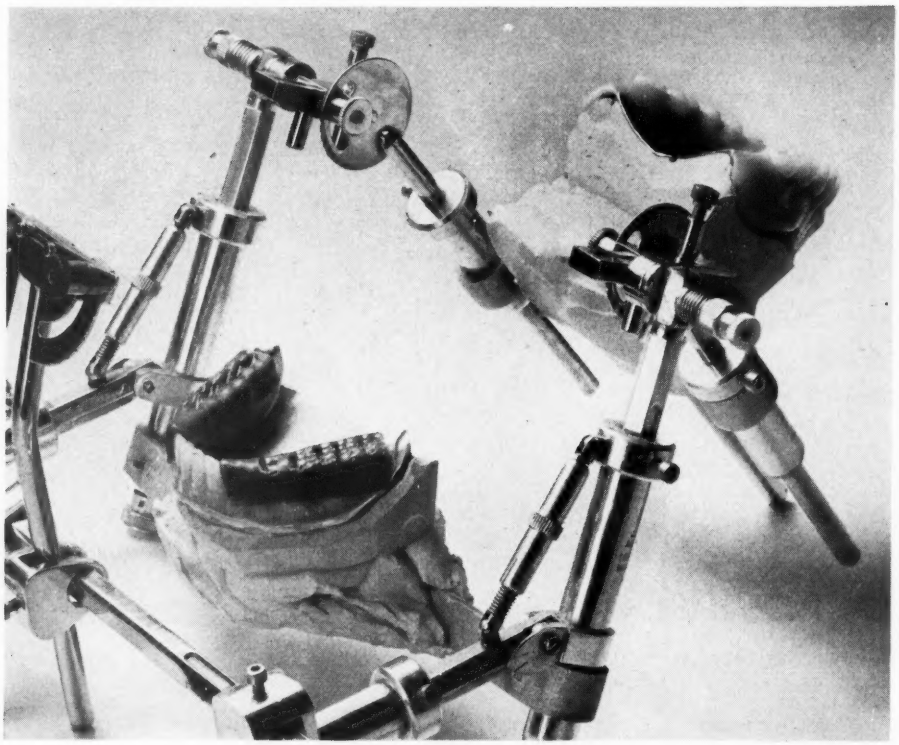

Fig. 4.—The completed chew-in record.

position through an arc of this magnitude is sufficient evidence that the instrument at least agrees with the "posterior border movements"[6] of the jaw. Our problem now is one of determining whether these posterior border movements correspond to the patient's movements and terminal positions in functional closure.

The posterior teeth of the lower denture have been dried, and then wrapped with four layers of a tacky wax, such as Kerr's adhesive wax or the equivalent thickness of Aluwax. The placing and thickness of the wax is shown in Fig. 3.

The dentures are inserted and the patient is instructed to regard the wax as an ordinary bolus of food that is to be chewed in a normal fashion. Lateral motions are neither ordered nor desired, as they are not part of a normal chewing stroke.

The operator need not instruct the patient further; in fact, he may leave the room and remain away until he feels that the chewing has progressed sufficiently to show the functional paths and terminal positions in the wax. He need not worry unduly over the possibility that the patient may penetrate the wax completely if the teeth have been arranged in a Transograph. Proper Transographic arrangement of teeth eliminates cuspal contact until the final occlusion. At the final occlusion, function has already ended. Therefore, there will be no preocclusal cuspal guidance involved, while an actual tooth contact at the end of the stroke will be prevented by the viscosity of the wax, just as contact is prevented in normal function by the viscosity of the interposed food.

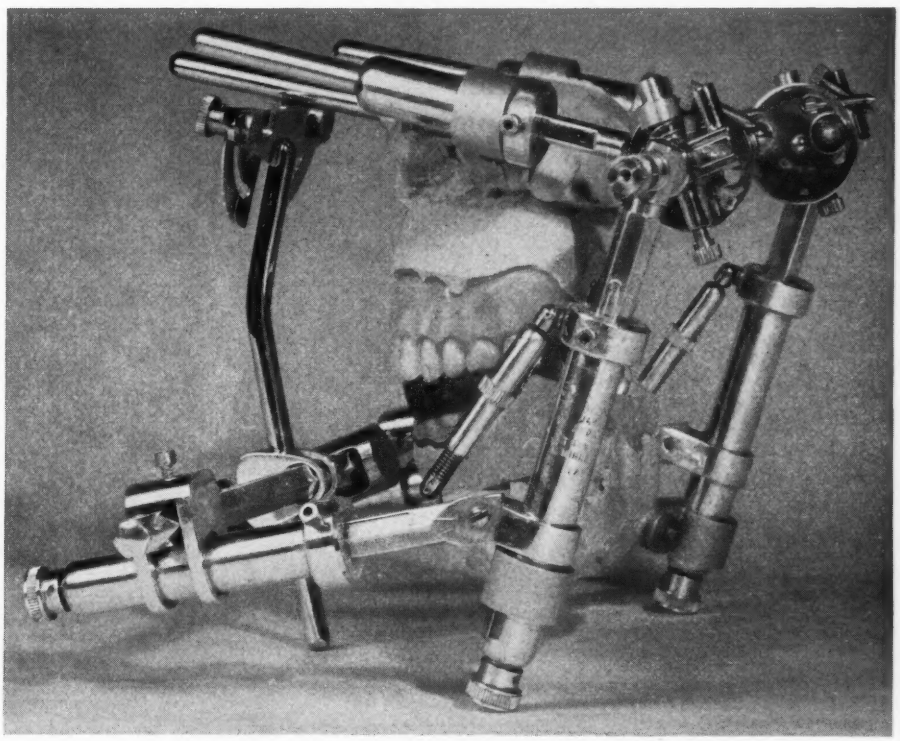

Fig. 5.—The teeth fitting perfectly into the chew-in record. This demonstrates that the original hinge record is accurate, and that the terminal position of function coincides with the hinge maxillomandibular record.

Fig. 4 shows how the wax has been chewed; the paths of jaw motion, as well as the terminal positions, are quite clear. Chewing has not quite penetrated the wax to a point where actual tooth contact would occur in the final occlusion. Fig. 5 shows that the Transograph accepts the chewed wax just as it accepted the static maxillomandibular records made with the jaw retruded forcibly. Fig.

6 shows the Transograph accepting a different thickness of chewed wax. The difference in occlusal separation is readily observed by comparing the distances between the stop bars and the anterior plane rods (the center rods in the upper frame of the Transograph) in both mountings.

This operation may be repeated as often as desired, and the functional results will always duplicate the results secured where the jaw has been manually and forcibly brought to the hinge position. Such duplication makes it clear that "strained" and "unstrained" relationships are the same whenever the condyles are in their hinge positions. It also proves that patients do close on a hinge axis function, because the Transograph is mounted to the patient's hinge axis.

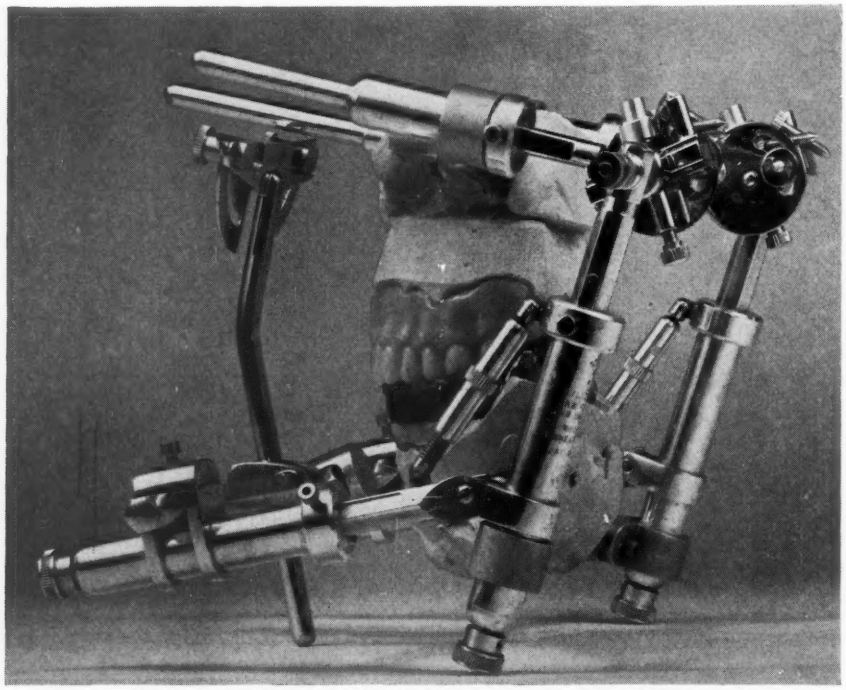

Fig. 6.—The teeth fit into a chew-in record made at an increased vertical dimension to indicate the validity of the hinge axis in relation to function.

CONCLUSIONS

That the same principles will apply and will prove true in the dentulous or semidentulous patient can be expected. Unfortunately, it is most difficult to make an actual demonstration in such patients because of the difficulty of removing and replacing the wax without tearing and distorting it badly, and thus compromising the true picture. Wherever it has been possible to remove and return the chewed wax maxillomandibular records without undue destruction, there has been little doubt as to the result. Again, it has been found that "strained" and "unstrained" relationships were identical when the condyles were in the hinge

position. It has also been demonstrated that function need be caught only in the final stages of closure (hinge range) for correct occlusion, and, that, during the final stages of closure, the jaw is arcing medially, vertically, and protrusively on the patient's hinge axis operating in conjunction with the Bennett movement.

It must not be assumed from the foregoing that *any* chewed record the patient delivers is a correct maxillomandibular record. Patients may and do deliver incorrect chewed records just as they may and do deliver incorrect hinge records. It is the dentist's duty to know, and his obligation to verify, that the jaw relationships delivered by the patient and mounted in the instrument are free from errors no matter what type of maxillomandibular record he may elect. It goes without saying that the articulator to which either type of record is transferred shall be capable of accepting them. It should also be able to confirm or deny the verity of any maxillomandibular record of any type. Nevertheless, it must still be realized that an articulator is not a brain—it is a tool. No matter how accurate or versatile it may be, it can do no more than reproduce what the dentist accepted from the patient.

The facts cited above make it clear that dentistry now has two choices of maxillomandibular record procedure—the conventional static record, or the functional or chewing record. What is even more significant and valuable, dentistry now has a means of double checking the mounting of the patient's jaw relationships. In the Transograph, prosthodontists have an instrument that is versatile enough to capture the patient's natural jaw function.

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AN ANALYSIS OF CURRENT CONCEPTS OF OCCLUSION

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PROSTHODONTISTS are primarily concerned with the problem of appearance, the maintenance of function, and the preservation of the remaining tissues of the masticatory system. Thus, within the limits of individual understanding and ability, a working knowledge of the anatomy and physiology of the stomatologic system has, of necessity, constituted an important instrument in the prosthodontist's armamentarium. It is gratifying to note the increase in the number of publications, and the work being done on the subject of occlusal function. Interest has not been aroused because the scope of occlusal function has been enlarged; the problem was always present. Rather, the interest has been aroused because of a more widespread and keener appreciation of the role played by occlusion in the function of the stomatologic system.

While there has been a laudable and necessary increase of interest in the subject, there has resulted, also, an outpouring of concepts, theories, ideas, and so-called studies, which, upon even cursory examination, are found to be mere repetitions that seem to be newly rediscovered by the author, and in truth are new only to him as an individual. Frequently, these "newer" ideas are presented in a blatant and flamboyant manner, and without a doubt do serve to bring the author to the forceful attention of the profession. While the objective of notoriety is served, the profession gains nothing.

More care could be used in the presentation of incomplete or inadequate experimentation as scientific proof to maintain a premise, or the validity of a subject or phase under consideration. Pseudoscientific jargon will only impress the uninitiated. A reminder of an elementary concept may not be amiss. An experiment or research project is not undertaken to "prove" or "disprove" anything, but rather to learn something more about the phase under study; and while making our studies "scientifically," an application of plain common sense may aid us in making a better evaluation of a "scientific" finding. Let the result of the experiment or research speak for itself. It is human to be charitable toward our own ideas and conclusions, but it is hardly scientific. The same yardstick that we use to measure the validity of the work we do ourselves should be applied to the work done by others. To state that the work done by one individual is not based on scientific fact or procedures, and then offer evidence in support of our own theories on a basis which is no more tenable scientifically, is ludicrous. An individual's opinion may be far from a fact; he has only the right to state an opinion. Time, and other individuals, will determine the facts. Quota-

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tions from other authors must be made with care. There is probably a great deal of truth in the statement, "People are never quoted; they are misquoted." Distortion of the writer's intent by short quotations is frequent; and misquotation should be carefully guarded against.

Nomenclature is never static, and, in a sense, may be used as an indicator of our changing world of concepts or ideas. Our adaptability toward our work and surroundings is frequently manifested by our ability to accept or reject changes in terminology. Ours is a comparatively new profession, and while, admittedly, many profitable changes may be made in our nomenclature, such changes should not be made capriciously or from the narrow viewpoint of an individual whose primary interest encompasses only a relatively small phase of our field. Changes should be made from the broader viewpoint of the individual whose field encompasses consideration of the entire stomatologic system. A definition which is tenable for one phase of dentistry should, if possible, be tenable for the other, if we are to speak a common language. While the definition of certain terms and concepts will probably remain controversial for an indefinite time, yet an effort should be made to correlate differences of opinion *without prejudice*. Changes in definitions should be based upon increased knowledge and understanding. They should never be based upon a narrow personal viewpoint.

Recent publications make it necessary for salient terms to be defined. This will be done, not from the standpoint of an individual whose main interest is in a limited phase of our work, but from the more catholic viewpoint of the clinician, and, more specifically, the prosthodontist, who must be well versed in all phases of the dental problem. Of course, in the evaluation of the terms used, clinical necessity must play an important part, otherwise our evaluation becomes didactically interesting, but clinically of little or no value.

CENTRIC RELATION

The definition of centric relation may be stated as follows: "Centric relation is the most retruded unstrained position of the condyles in the glenoid fossae at any given degree of jaw separation from which lateral movements can be made." Centric relation is a condyle fossa relationship, and primarily an anteroposterior relationship.

Analysis of the definition will indicate exactly what the prosthodontist has in mind, and the concept denoted is perfectly correct anatomically and physiologically. For analysis, the definition may be broken up into three parts:

1. It " . . . is the most retruded unstrained position of the condyles in the glenoid fossae . . ."

The "most retruded unstrained position" is constant and can be recorded as many times as is desired throughout life. In recording centric relation, no other position anterior to this most retruded unstrained position can, based on the laws of probability of chance, be recorded twice. The clinical value of this situation will be pointed out later. Note that the definition carries the word "unstrained." Since the individual can assume this most retruded position voluntarily by the action of his mandibular musculature, the position is, of course, unstrained.

2. ". . . at any given degree of jaw separation . . . " This phrase means simply what it says. Centric relation can be recorded in any vertical position of the mandible from one of extreme overclosure to one of overopening.

3. " . . . from which lateral movements can be made." This serves to call attention to the fact that it is impossible for the individual to make lateral movement when the mandible is opened to its greatest extent, and that there must be no "forced" retrusion—a position from which the individual can certainly make no lateral movement.

Because the position of centric relation represents the "most retruded unstrained position," it is of course a "border" or "terminal" position. Dissension and confusion about this position and its definition arise only when there is a lack of differentiation between centric position and the neutral condylar position. The neutral condylar position will be described in conjunction with rest position.

Perhaps a just criticism of this definition can be made on the basis that it does not cover enough ground. For instance, in making a registration of the position of centric relation, the registration must be made with the utmost regard for equalization of pressure. By whatever means employed, or medium used for making the registration, the factor of equalization of pressure must be incorporated or the registration becomes inaccurate and worthless. With a natural dentition, a lack of equalization of pressure may occur because of (1) the mobility of the teeth, if they are used to support the registering mechanism or interposing media, and (2) the actual pulling down of one or both of the condyles because of premature contacts of the registering mechanism or registering medium. In constructing complete dentures, the latter factor must be recognized as a potentiality, together with the possibility of unequal displacement of the tissues underlying the registration bases in edentulous mouths.

Unequal tonicity of the attaching muscles may produce a registration which does not reveal its inaccuracy immediately. For example, if for some reason the attaching muscles on one side of the jaw are incapable of exerting as much contractive power as the muscles on the other side of the jaw, the condyle on the side of the lessened contraction will not be brought back to its most retruded position. Tracings or interocclusal records of the position of centric relation can be checked repeatedly with the condyles in this position. Since no indication of the inherent inaccuracy is manifested in the registration, the condylar position thus obtained is registered and utilized in the treatment indicated.

After a varying period of time, an examination of the individual's occlusal relation will reveal a disharmony of occlusal relation which can be attributed to no other reason than the regaining of muscle tonicity on the affected side.

REST POSITION

Rest position may be defined as "the position which the mandible assumes when the attaching muscles are in a relaxed state of tonic equilibrium." Rest position should be noted when the individual is in an upright position with the head in a position which places the Frankfort plane in a horizontal position.

With the mandible in rest position, there are two main points which come under discussion: (1) the constancy and amount of interocclusal clearance (free-way space) which exists when the mandible is in rest position, and (2) the position the condyles assume, in relation to the glenoid fossae, when the mandible is in rest position.

As was pointed out by Thompson,[1] the rest position has a high degree of stability. In other words, the rest position remains fairly constant over relatively long periods of time. This observation has been of considerable value in its clinical application. The difficulty which has arisen is based upon a misinterpretation of Thompson's statistical study of the amount of interocclusal clearance which exists when the mandible is at rest. For example, the conclusion reached from his first study[1] indicated that the amount of interocclusal clearance *averaged* 2 to 3 mm. Incorrectly, 3 mm. has become the yardstick generally used to determine interocclusal clearance, especially where the construction of complete dentures is concerned. Clinically, the universal acceptance and application of this 3 mm. average would prove disastrous. More recently the same author[2] stated that, "the rest vertical dimension established by the mandible in its rest position is greater than the occlusal vertical dimension, and it is constant in most instances regardless of the status of the dentition. The difference in the two face heights should be approximately 2, 3, or 4 mm., and this is the average allowance for the free-way space or interocclusal clearance that exists between the maxillary and mandibular teeth when the mandible is in rest position." Sicher,[3] on the other hand, states unequivocally that, "In rest the mandible drops slightly, the incisor teeth are separated by 2 to 5 mm., the lips are lightly closed." Actually, the figures given by Thompson and Sicher are of statistical interest only. The only thing that can be said about the amount of interocclusal clearance which an individual will exhibit is that *some amount* of interocclusal clearance does exist. The amount of clearance to be permitted an individual patient, clinically, must not be considered on the basis of approximate or average distances. It must be determined in conjunction with other factors, such as, apparent tooth wear if natural teeth are present, facial contour from both the frontal and sagittal views, *muscle tone,* artificial tooth (anterior and posterior) positions, phonetics, etc. An interocclusal clearance of only 1 mm. is frequent; one of 6, 7, or 8 mm. or more is not infrequent.

Now let us consider, "the position the condyles assume in relation to the glenoid fossae when the mandible is in rest position." When the mandible assumes the rest position, the attaching muscles are in a relaxed state of tonic equilibrium. The condyles are, so to speak, *suspended* in the glenoid fossae, and the teeth are out of contact. From this position, the mandible can, by voluntary action on the part of the individual, be moved upward, forward, laterally, and distally, or in any combination of these movements. Thus, the condyles are in a neutral position. To insist upon calling this position "centric position" is fallacious.[3] In this neutral condylar position, the condyles are not in the center of the related structures, because from this position the condyles can make considerable movement anteriorly, but very limited movement posteriorly. On the other hand,

reference to the "most retruded unstrained position" of the condyles as the centric relation (center) is supported by the presence of a terminal hinge axis around which the mandible rotates, and the hinge axis line about which the movement takes place. The significant point to keep in mind is that the condyles are in a neutral position when the mandible is in rest position, and that the neutral position *is not* the position which the prosthodontist seeks to register when he is registering the position of centric relation.

Maximum occlusion may be defined as "that occlusal position in which the teeth are making maximum contact." This definition would hold true whether natural or artificial teeth are being considered.

Centric occlusion may be defined as "the position in which the teeth are making maximum contact, and the condyles are in the position of centric relation," that is, the "most retruded unstrained" position. Thus, when considering a natural dentition, the teeth are rarely in centric occlusion as defined, even though they are making maximum contact. Whether this is "normal" or due to slight deviations from growth patterns, the fact remains that many individuals, with an apparently unmarred dentition, are capable of moving their jaws back slightly (translatory movement) to the position of centric relation from the position of maximum occlusal contact. As long as this change in condylar position between centric relation and maximum occlusal contact remains within the limits of physiologic tolerance, no apparent untoward effects occur. It is certain, however, that as tooth wear, loss of teeth, placement of faulty restorations, and other factors causing a perceptible malocclusion occur, the condyle position becomes seriously altered with accompanying untoward sequelae. Either damage occurs to the temporomandibular joint, or the supporting structures of the teeth break down, or both.

Thus, while the anatomic relationship of the structures concerned (the temporomandibular joint and the natural teeth) is understood, the criteria to be used in determining the amount of difference between the position of centric relation (condyle position) and the maximum occlusal contact which is physiologically acceptable is conjectural, since no criteria have been or probably can be established. Individual variations from "normal," which are apparently functioning within the limits of physiologic tolerance, will make the establishment of such criteria difficult, if not impossible, when one is dealing with a subclinical malocclusion.

Fortunately, our treatment of a *recognized* malocclusion does not require the establishment of a definite yardstick to determine the amount of difference between the position of centric relation and maximum occlusal contact, which is within the limits of physiologic tolerance for the individual.

Significantly, the technique advocated in the treatment of malocclusion of natural teeth, for the detection and alleviation of premature contact, is accomplished by endeavoring to have the patient close the jaws in the position of centric relation ("most retruded unstrained"), and then noting the point or points of premature occlusal contact by one means or another. This treatment is consistent with the anatomy and function of the parts involved. As was pointed out, the individual can cause the condyles to be brought into their "most retruded position" by voluntary muscular contraction. Therefore, occlusal correction must,

of necessity and desirability, start from this position and from no other position, since the objective of the treatment is to eliminate the malocclusion within the *entire* range of possible occlusal contact.

The logic for the selection of the "most retruded unstrained position" (the position of centric relation) as the starting point for the correction of malocclusion, occlusal reconstruction, and denture construction can be easily demonstrated by means of a needle-point tracing.

Fig. 1.—*A*, The blunted apex usually obtained in the initial attempt to make a tracing. *B*, A properly apexed tracing.

When making a needle-point tracing for establishing centric relation on a patient with a "normal" temporomandibular joint, the apex of the initial tracing will be rounded frequently instead of having a definite apex (Fig. 1,*A*). Aside from technical factors involved (instability of trial bases, interference between the bases at the distal ends, lack of equalization of pressure, etc.), the rounded apex may, in general, result from the patient's failure to understand what is required when the right and left lateral movements are made, habit ("acquired eccentric"), or a slight filling in of tissues behind one or both of the condyles. This latter factor plays an important role, the significance of which has probably not received adequate recognition.

In all such conditions, it will be found that, with some persistence on the part of the patient and operator, the patient will produce a needle-point tracing with a definite apex (Fig. 1,*B*). Not infrequently, this objective is reached only after several appointments. Sedation may be indicated to relax the patient.

Suppose that the blunted apex of the needle-point tracing had been accepted as the position of centric relation, and that occlusal reconstruction, correction of occlusal disharmony of natural teeth, or denture construction had been completed. With this as the starting point, the results would be disastrous. In occlusal reconstruction, or correction of occlusal disharmony, a definite malocclusion would result whenever the patient decided, of his own volition, to close in the more retruded position (at the apex of the tracing) (Fig. 2). In complete denture construction, the resulting area of malocclusion (Fig. 2,*B*) would produce an inevitable shifting and sliding of the denture bases, which would result in instability of the dentures and all of its undesirable sequelae.

Since it is recognized that the individual will undoubtedly make many initial tooth contacts which vary from the most retrusive position (at the apex) to a slightly anterior (eccentric) position (on the blunted apex), provision must be made to avoid "grooving" the patient to the most retruded position before inclined

plane contact is made. If cusp teeth are used, this is accomplished by allowing for "free play." To allow for "free play," a slight widening of the central grooves or fossae of the posterior teeth is made to provide an area larger than the size of the cusp which fits into the groove or fossa when initial tooth contact is made. Thus, provision is made for a limited range of horizontal movement of the mandible without engaging the inclined planes of the teeth.

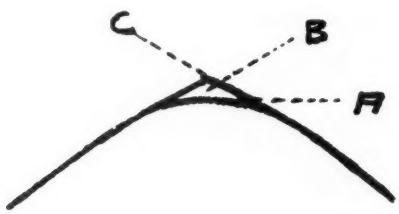

Fig. 2.—*A*, A blunted apex. *C*, The apex of the tracing. *B*, The area of malocclusion which would result if *A* were accepted as the position of centric relation.

HINGE AXIS

The presence of a terminal hinge axis and center of rotation from occlusal position through, and, in many instances, greatly beyond, the rest position level, has been demonstrated repeatedly. The fact that the registration of the hinge axis involves a "learned" movement in no way invalidates its accuracy or usefulness. Quite properly, the position of the condyles during the making of this registration has been labeled a "border" or "terminal" position. As with centric position, it is precisely because the hinge axis represents the "border" position that it is capable of being recorded repeatedly with unfailing accuracy. The importance of the location of the hinge axis position is predicated on the conviction that (like centric relation) registration of condylar paths which include the Bennett movement (the side shift of the condyles in the glenoid fossae) should be made from the hinge axis position which forms the starting point for eccentric movements. Accurate transfer of these records to an articulator which is capable of reproducing these positions and paths of movements is desirable in order to produce an harmonious occlusion.

Much controversy seems to revolve around the question of whether or not closure from the rest position to the occlusal position is a hinge axis movement. Much of the dissension which exists is based on the use of incorrect nomenclature, and upon failure to distinguish between the directions of movement which the individual can make when closing from rest position to occlusal position. When a closing movement is made, the general direction and range of closure may vary greatly. For example, the patient may close in lackadaisical movement with the condyles at some distance from their most retruded unstrained position. Registration of this closure would indicate, of course, that the patient was not making a simple hinge axis closure, but more likely a closure which included translatory

movement. If, on the other hand, the patient was to instigate muscular contraction voluntarily, sufficient to bring the condyles into their most retruded unstrained positions during a closing movement, the resulting mandibular movement would be, without question, a hinge axis movement. Our concept should be clear on one point: Closure from rest position to occlusal contact may, and frequently does, involve rotatory movement, translatory movement, or combinations of both. Since the mandible is capable of making both types of movements, unquestionably it will function in such a manner as to utilize its full potentiality of movement at some time or other, during both masticatory and nonmasticatory function.

ENVELOPE OF MOVEMENT

All movement is functional. It is incorrect to speak of movement as being nonfunctional. Movement may be described as masticatory, nonmasticatory, reflex, gliding, etc. When there is movement, there is function, regardless of the nature of the movement.

Mandibular movements during mastication and speech are varied and complex. The temporomandibular joint is a ginglymoid-arthrodial joint (sliding-hinge joint) and far from a universal joint. However, the adaptability of the joint, within the limits of physiologic tolerance, has lead to much misunderstanding. The entire concept is further complicated by the fact that the limits of physiologic tolerance are highly variable with different individuals. It is not uncommon to find individuals with pronounced malocclusions who show no clinical evidence of either temporomandibular joint involvement or pathologic involvement of the supporting tooth structure. Conversely, other individuals have barely discernible malocclusions which have resulted in clinically perceptible temporomandibular disturbances.

The existing potentiality of a wide range of physiologic tolerance does not imply that movement of the joint is vague and free-swinging. The contrary is true. The envelope of movement of the condyles, made within the boundaries of any selected range of movement, are quite constant and deviate therefrom only because of possible tissue displacements, which must fall within the limits of physiologic tolerance if the joint is to remain healthy. In other words, the movements are not as constant as those made by two well-machined metal parts of a machine, but most certainly they are as constant as any relationship which can exist between healthy, living tissues.

While our major concern is with movements which take place from the moment of initial occlusal contact to the terminal point of tooth contact in any given masticatory cycle, an understanding of the general pattern of the entire masticatory stroke during the chewing cycle is necessary. To obtain a clear, concise picture of it, the cycle must be considered in a three-dimensional relationship: From the frontal, horizontal, and sagittal aspects.

Repeated tracings on a frontal plane indicate that the movement is essentially one of opening, followed by a side shift laterally, and finally an upward and inward movement. From the sagittal aspect, the movement does not fall within a pattern as well defined as the pattern of movement on a frontal plane. In general, the

movement will consist of a slight protrusion, which is associated with the eccentric positioning of the mandible on opening, and then an upward and backward movement. The completion of the masticatory stroke is generally toward centric relation if the bolus of food offers sufficient resistance. Movement on a horizontal plane will follow the path generated as in an arrow-point tracing. These are only generalized patterns and many deviations may be observed frequently.

Kurth,[4] in his article describing the use of Edgerton's stroboscopic light in the study of masticatory movements, and in later publications, insists that "the most important discovery was made in the horizontal plane, where it was found that the masticatory stroke is not within the confines of the Gothic arch, but posterior to centric relation."

Of course, Kurth's error in observation was made in interpreting a three-dimensional movement on a two-dimensional photograph. This error of observation lead to the foregoing statement, which, of course, is an impossible conclusion.

Fig. 3.—*A*, The direction of a tracing obtained when the stylus is attached to the mandible and the recording plate to the maxilla. *B*, The direction of a tracing obtained when the stylus is attached to the maxilla and the recording plate to the mandible.

There are several salient factors which must be considered when making an arrow-point (Gothic arch) tracing. An arrow-point tracing may be made at any given degree of jaw separation from overopening to overclosure, provided the patient can make sufficient lateral movement to make the registration. By the very nature of the method by which the tracing is made, the apex of the Gothic arch represents the most retruded position of the condyles in the glenoid fossae. The only means by which a more retruded movement could be made is by the application of heavy, continuous distal pressure on the mandible during the making of lateral movements. This latter would, of course, be an almost impossible situation. That the apex represents the most retruded position is true, whether, during the making of the tracing, the stylus is attached to the mandible and the recording plate attached to the maxillae (Fig. 3,*A*), or in the reverse, with the stylus attached to the maxillae and the recording plate attached to the mandible (Fig. 3,*B*). The tracings used by Kurth corresponded to the former. In his study, the steel ball attached to the interproximal space between the mandibular central incisors corresponds to the stylus, and the photographic plate corresponds to the recording plate. Whether the photograph was made from above or below the patient's head would in no way change the photographic record.

The initial movement of the masticatory stroke may start from occlusal contact, rest position, or a wide-open position. The successive strokes used in masticating a bolus of food may start from tooth contact (if bolus penetration has been accomplished), or from a greater degree of opening, depending upon the size and

nature of the bolus being masticated. The point to remember is that if the action is stopped at successive levels, a Gothic arch tracing can be made, and all movement on that level will fall confined within the limits of the tracing with the most retruded position at the apex of the tracing. To illustrate this point, tracings of opening and closing movements on a sagittal plane were made following the technique used by Parks,[5] i.e., the stylus is attached to the mandible of an edentulous patient, the patient is instructed to make opening and closing movements, and an

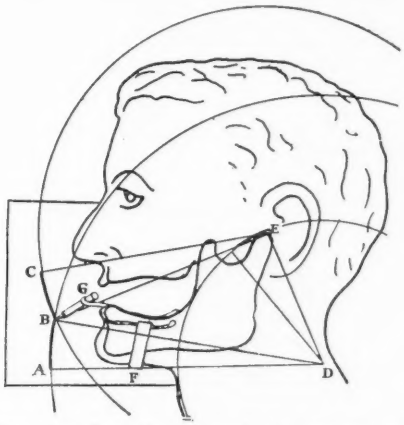

Fig. 4.—Park's technique for scribing a sagittal tracing of the opening and closing movement. (From Parks, in Nichols, Prosthetic Dentistry.)

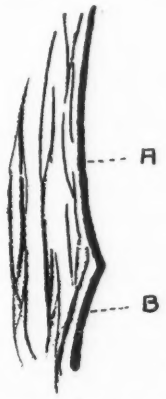

Fig. 5.—A sagittal tracing obtained by Park's technique. The heavy line forming arc *A* represents the most retruded position obtained. The heavy line *A* is the first part of the arcing movement (hinge axis), and *B* the second part of the movement made on a sagittal plane. Arcs *A* and *B* represent the "most retruded unstrained position," which the mandible can assume. The lines to the left of arcs *A* and *B* represent eccentric registrations. Note that all eccentric movements of the mandible take place within the included angle of the Gothic arches formed at successive levels.

effort is made to retrude the mandible during these movements. The record is made by holding a piece of cardboard against the patient's face and the recording stylus (Fig. 4). Fig. 5 illustrates the type of tracing obtained. The upper segment of the arc *A* indicates the first segment of the hinge axis movement; *B* indicates the arc formed by the change in rotational center. A composite drawing of move-

ment on the horizontal and sagittal plane (Fig. 6) may be used to illustrate the entire envelope of movement, and that *all* eccentric movements of the mandible are contained within the included angle of the Gothic arch. The heavy, black line formed by the arcs *A* and *B* represent the most retruded position of the condyles in the glenoid fossae, which on the horizontal plane correspond to the apex of the Gothic arch and, hence, centric relation at successive levels of mandibular opening. All marks to the *left,* within the included angle formed by *RL* and *LL,* represent protrusive and right and left eccentric movements. If Kurth were correct in his statement, mastication would have to take place to the *right* of the heavy lines, which is manifestly an impossibility.

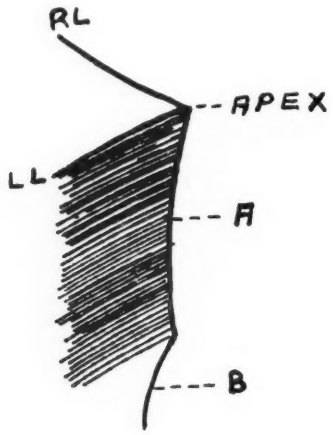

Fig. 6.—A composite drawing of the eccentric movements which can be made at various degrees of jaw separation. The apex of the arrow-point tracing will always be on the arcs *A-B* from which the right (*RL*) and left (*LL*) lateral movements will take place. It is impossible for movement to take place to the right (more distal) to the arcs *A-B*.

From the preceding discussion, it will be seen that the fundamental differences in concepts of occlusion will vary with (1) individual interpretation of mandibular movements, and (2) techniques and appliances best suited to accomplish the requirements of the various concepts. The two should not be confused.

Occlusal concepts fall into three general categories: (1) balanced occlusion, (2) spherical occlusion, and (3) nonbalanced occlusion. Spherical occlusion may be classified as nonbalanced occlusion. It is my opinion that the concept of balanced occlusion is tenable and sound, but I will not label "any individual who dares to question this ideal as being ignorant or not worthy of consideration,"[6] as Kurth suggests.

The concept of balanced occlusion was well stated by Stansbery[7]: "Balanced occlusion involves a definite arrangement of tooth contacts in harmony with mandibular movement." To concur with this concept involves the acknowledgment and acceptance of three main factors: (1) the relative immutability of condylar movement, (2) the presence of eccentric mandibular movement during function, and (3) the possibility of arranging tooth contacts in harmony with the resultant mandibular movements.

There is nothing "geometrical" about an occlusion arrived at by the acceptance of these factors, nor is it based on a "hypothesis of spherical congruency." Quite the reverse is true. The resultant occlusion will represent an attempt to individualize the occlusion to fit the pattern of one particular individual; in other words, it is a concept which permits the occlusion to be adjusted to the patient instead of adjusting the patient to the occlusion.

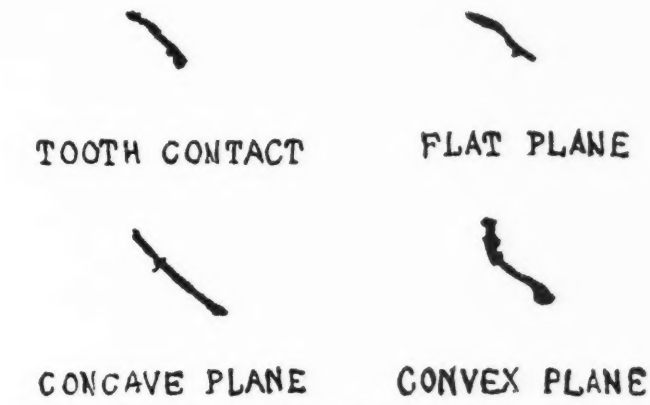

Fig. 7.—Tracings made by Kurth and offered to indicate "the wide variance of condylar angulation traced graphically in the sagittal plane."

RELATIVE IMMUTABILITY OF CONDYLAR MOVEMENT

The mandible is capable of an infinite number of movements which are either rotary, translatory, or combinations of rotation and translation. The movements can be made at varying degrees of jaw separation. In the edentulous patient, these movements are controlled by the temporomandibular joints. In general, the paths which the condyles follow in the glenoid fossae are determined by (1) the bony limitations which comprise the joint, (2) the direction and tonicity of the attaching muscles, and (3) the limitation of movement imposed by attaching ligaments. When a natural dentition is present, the leading role in the dictation of the condylar path is played by the teeth. The evidence for the assertion that there exists a relative immutability of the paths of movement of the condyles in the temporomandibular joints beyond the range of physiologic tolerance is based on the frequent clinical observation of temporomandibular joint disturbances which can readily be ascribed to the presence of a malocclusion.

The breakdown of the joint occurs because of its constant malpositioning beyond the range of physiologic tolerance, caused by the lack of cuspal harmony with mandibular movement each time tooth contacts are made. It is true that, in the presence of malocclusion, it is not always the joint which suffers the apparent brunt of the ensuing pathologic condition. Frequently, the havoc is manifested in a breakdown of the tooth-supporting structures, giving further evidence that the mandible pursued a relatively inflexible path of movement.

If the temporomandibular joint enjoyed the latitude of free movement and adaptability which some individuals claim it is capable of, then there would be no

such pathologic entity as a temporomandibular joint disturbance directly traceable to a malocclusion, and very few teeth would be lost because of traumatic occlusion.

Kurth[6] recently described an experiment and offered tracings to indicate "the wide variance of condylar angulation traced graphically in the sagittal plane from tooth-to-tooth contact, as compared to the tracings obtained [on] a flat, concave, and convex plane." These tracings are shown in Fig. 7. A cursory examination of these comparative tracings reveals an interesting fact. While the tracings are offered to indicate that condylar tracings change from one set of conditions to another, namely, tooth contact, flat plane, concave plane, and convex plane, *the average inclination of the four tracings is almost exactly the same.*

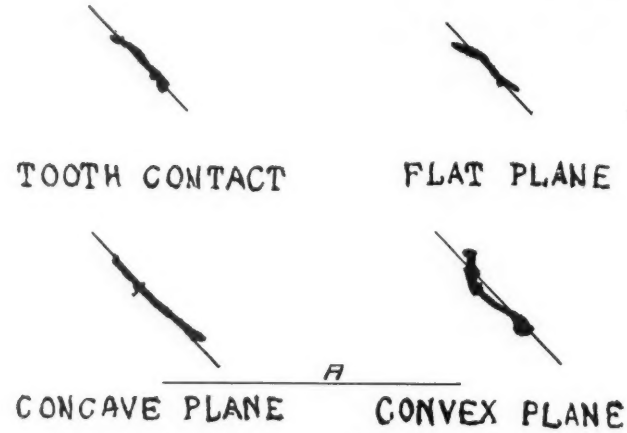

Fig. 8.—A copy of the tracings in Fig. 7. A base line *A* has been drawn. It was found that the mean average inclination of the four tracings was 45°.

Fig. 8 is an enlargement of the original illustrations. A 45° triangle was placed upon a base line drawn to the four tracings, and the mean average inclination of the tracings was made. It will be noted, this mean average is almost exactly 45° for each of the tracings. It must be noted, too, that the tracings were made at two different degrees of jaw separation, and yet the average angle remained the same. The evidence offered by Kurth may, therefore, be accepted as additional evidence of the relative immutability of the condylar path, rather than the opposite view, as he intended.

The deviations from more exact reproductions of the condylar tracings call for only elementary explanation on two grounds. (1) *Anatomic:* As was pointed out, in patients with malocclusion of natural teeth, the condyles must follow the path dictated by the teeth, and the degree of distortion will be in direct proportion to the degree of malocclusion present. (2) *Technical:* Since a central bearing point tracer was used to maintain contact with the flat, concave, and convex planes, the necessarily eccentric position of the central bearing point, while making the tracings, can and will cause further distortion of the condylar movements. Boucher[8] pointed out, "All three dimensional articulators require the use of centric, lateral, and protrusive check bites for their adjustment. We have observed errors in the occlusion of dentures built on this type instrument when a central bearing

point was used in obtaining these check bites. Part of this error was believed to be due to a *mechanical reduction of the space between the maxillae and mandible when eccentric records were taken.*" Lack of equalization of pressure on the mucosa will also produce varying degrees of distortion in the tracings.[9]

Because of the inherent errors present with the use of a central bearing point, it may be stated categorically that any technique or procedure based on the use of a central bearing point cannot be considered accurate.

PRESENCE OF ECCENTRIC MANDIBULAR MOVEMENTS

Mandibular movement and the need for cuspal harmony are further questioned by some individuals on four counts: (1) the direction, (2) the degree or amount of tooth contact made during functional movement, (3) whether or not tooth contact is made during the mastication of a bolus of food, and (4) the difference between movement made by the jaws and the equivalent movement made on the articulator.

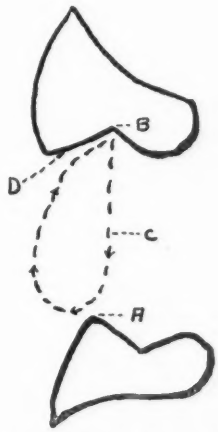

Fig. 9.—On a frontal plane, cusp *A* makes contact at *B* and travels the path indicated by the broken line *C*.

DIRECTION OF MOVEMENT

The direction of masticatory movement on a frontal plane has been repeatedly demonstrated, and, in general, is elliptical or "teardrop" in shape (Fig. 9). Cusp *A*, from centric contact at *B*, travels the path indicated by the broken line *C*. If the bolus of food is penetrated, initial tooth contact will be made by cusp *A* with the inclined plane *D* close to the tip of the buccal cusp. Contact will be maintained through to centric occlusion, and not infrequently beyond this range, to the extent that the lingual incline of the mandibular buccal cusp will continue to make contact with the buccal incline of the maxillary lingual cusp before the cycle is repeated.

DEGREE OF AMOUNT OF TOOTH CONTACT MADE DURING FUNCTIONAL MOVEMENT

Hildebrand [10] stated that tooth-to-tooth contact from the position of eccentric contact to centric occlusion *averages* between 1 and 2 mm. at the incisor point. It

must be kept in mind that 1 and 2 mm. represent average figures, which means that in some individuals there may be no appreciable amount of movement involved, while in others there may be movement involved greatly in excess of 1 or 2 mm. Following a rough rule of thumb, the eccentric movement which takes place at the first premolar tooth is approximately two-thirds of the movement at the incisor point. Thus, the movement at the first premolar will be 0.66+ mm. for every 1 mm. of incisor point eccentric movement of which a patient may be capable. To say that a lack of cuspal harmony may be ignored, even within the minimum limits of the possible eccentric movement of which the patient is capable, is fallacious. To insure freedom of movement for potentially large ranges of movement, cuspal harmony must be provided for from possible cusp-to-cusp contact in the eccentric position to and through the termination of the movement in centric relation position. The statement that individuals do not "normally" use their full potentiality of eccentric movement is not based on fact.

TOOTH CONTACT DURING THE MASTICATION OF FOOD

The suggestion has been made that tooth contact rarely, if ever, occurs during the mastication of food. The same thought was expressed by Prime in his famous statement, "Enter bolus, exit balance." The natural deduction is intended to be that balanced occlusion is unnecessary. Here we find that a broad generalization is established as a major premise. This has not been supported by sufficient acceptable scientific evidence.

Actually, whether or not tooth contact will take place during the mastication of food will depend upon three main factors: (1) the type and size of the food bolus being masticated, (2) the occlusal pattern of the teeth being used, which will influence the relative ease or difficulty with which the food bolus may be penetrated, and (3) the vigor with which the individual attacks the food bolus.

As for the type and size of the bolus of food, it is obvious that if the bolus is too large, penetration will not occur, if for no other reason than that the patient will be unable to position the bolus satisfactorily for mastication to take place. All foods do not present uniform resistance. Some are penetrated so easily that tooth contact is inevitable, while other foods are so resistant and fibrous that penetration cannot be expected to occur. Between these two extremes are the foods which must be macerated by the teeth in relatively slow stages until the bolus has been reduced to a fine mixture. It is during these final stages of mastication that tooth contacts are inevitable.

The factor of relative tooth sharpness is subject to constant attention. Increased depth and number of sluice ways, narrow buccolingual tooth width, and further lessening of occlusal resistance by elimination of a posterior tooth are some of the various means employed to diminish stress and to increase the ease of food penetration. Occlusal surfaces which permit easier penetration and maceration of the bolus may reasonably be expected to increase the probability of tooth contact during the act of mastication.

Given a constant, insofar as the bolus of food and the occlusal pattern of the teeth is concerned, the expectancy of tooth contact will be diminished or increased

depending upon the vigor with which the patient masticates. The element of time which the patient takes in masticating a particular bolus must not be ignored. It should be pointed out that the factor of vigor exerted by the patient in masticating food is an important reason why the value assigned to chewing tests made in experimentation must be evaluated with caution.

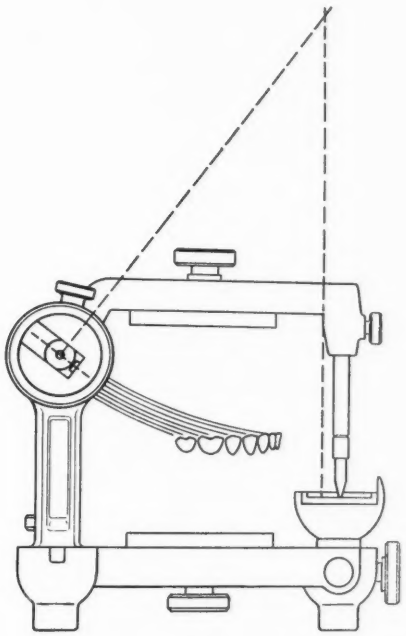

Fig. 10.—The location of the rotational center when the condylar inclination is 37° and the incisal guide angle is 0°. (From Swenson, Complete Dentures, ed. 1.)

Our only concern, however, is not restricted to a consideration of whether or not teeth make contact during the mastication of food. Balanced occlusion will exhibit its greatest properties of stabilization during the many hours when food is not being masticated. It is irrefutable that tooth contact takes place thousands of times a day. Such contacts occur during speech, swallowing, and nonpurposeful closures which take place in centric and eccentric positions.

ARTICULATOR AND JAW MOVEMENTS

Articulators are used as instruments of convenience. They are the result of study and analysis of mandibular movements and jaw relation, and are designed to permit the accomplishment of the concepts of the individual who constructed the machine. Thus, the statement that "balanced occlusion is a 'geometrical ideal' or is based on 'hypothetical articulator movement'" is not quite fair to such articulator designers as Stansbery, Terrell, McCollum, Gysi, Phillips, and others. The implication that the articulator was first designed and constructed, and then

a rationale of mandibular movement and jaw relation conceived to fit the articulator, is unwarranted.

It is agreed that the movements reproduced on many semiadaptable and three-dimensional instruments are not an *exact* reproduction of mandibular movement. Living tissues do not function with the low tolerances possible in machined parts. Of necessity, the registrations made on living tissues will exhibit a certain degree of variation. Nevertheless, transference of these records to a mechanical device can be done with a relatively high degree of accuracy so that both the degree and general direction of movement dictated by the records can be quite closely duplicated or made equivalent.

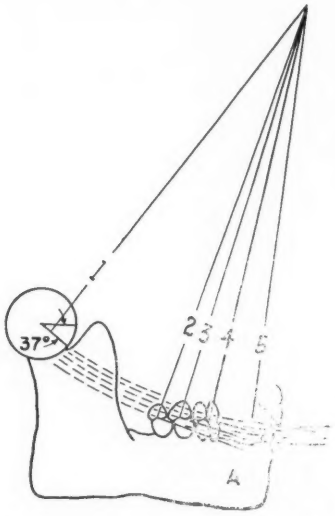

Fig. 11.—A diagrammatic drawing of the mandible and teeth showing same relationship as Fig. 10. (From Swenson, Complete Dentures, ed. 1.)

For practical purposes and convenience in handling, most articulators are constructed with the upper member movable. The construction of an articulator with a stationary upper member and a movable lower member presents no particular mechanical problem. Such a machine was demonstrated to me as far back as 1936 by Miller. In my opinion, the machine was rather cumbersome. It has also been recognized that in eccentric movement a slight error is eliminated by making the lower member of the articulator movable. Perhaps Bergstrom,[11] by the construction of his Arcon articulator, has succeeded in overcoming objectionable cumbersomeness and increased the accuracy of reproduction of mandibular movement.

In discussing Schuyler's[12] "very complete geometric procedure" for the removal of occlusal interferences, Kurth[6] states that because of the movement of the upper member of the articulator, "it doesn't make any difference what technic is used to set the condylar adjustments, the center for the lateral and the protrusive movements can be demonstrated to arise in an area above the upper member of

the articulator . . . consequently, the use of the articulator freezes this motion." The use of an articulator with a movable upper member by no means freezes "the center for the lateral and protrusive movements." The center of rotation is determined by the condylar inclination *and* the incisal guide angle. Fig. 10 shows the determination of the center of rotation when the condylar inclination is 37° and the incisal guide angle 0°. Note that in this case the center of rotation is above the upper member of the articulator. Fig. 11 is a diagrammatic drawing of the mandible and teeth, showing the same relationship. Note that the two central incisors are set with a vertical and a horizontal overlap which results in a 0° incisal guide angle. Fig. 12 indicates the change in the center of rotation which occurs when a plus incisal guide angle is used. This clearly demonstrates that movement of the upper member of the articulator does not interfere with the changes in the center of rotation as demanded by varying the degree of incisal guide angle used to accommodate any particular situation, and that the equivalent of mandibular movement does take place. Therefore, the pattern for the removal of occlusal interference, as presented by Schuyler, is correct.

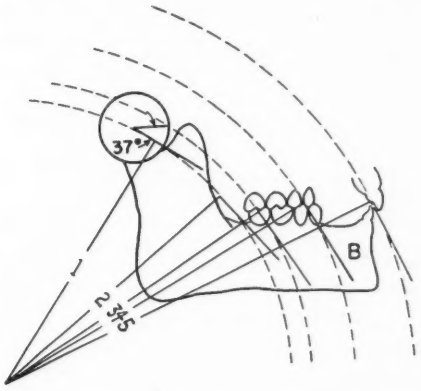

Fig. 12.—The change of the center of rotation on an articulator when a plus incisal guide angle is used. (From Swenson, Complete Dentures, ed 1.)

POSSIBILITY OF ARRANGING TOOTH CONTACTS IN HARMONY WITH RESULTANT MANDIBULAR MOVEMENTS

Tooth contacts may be arranged in harmony with mandibular movement by considering three factors: (1) condylar inclination, (2) incisal guide angle, and (3) cusp angle. As has been indicated, condylar inclination is determined by the patient and forms one end factor. *The dentist has no control over this factor.* The second end factor is determined by the incisal guide angle. This is the angle formed by the vertical and horizontal overlaps. Within broad limits, the degree of incisal guide angle is almost entirely within the control of the operator. He may increase or decrease it at will. The mandible will follow any degree of incisal guide angle selected, and will do so without the slightest change in its own path of movement.

With the two end factors determined, harmony of tooth contacts in the centric and eccentric movements will take place as soon as the teeth are set at the resultant angle, i. e., the angle of mandibular movement which results from following the path of movement determined by the condylar and incisal guide angle. The result will be balanced occlusion and stabilized dentures.

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THE WHY AND HOW OF CUSPAL HARMONY IN THE LATERAL RANGES

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THIS ARTICLE IS LIMITED to a presentation of an easily understood and employable technique for establishing cuspal harmony in the lateral ranges of occlusion for (a) those patients in which no change is made in the vertical maxillomandibular relationship, and (b) those patients in which the vertical opening is increased. Cuspal harmony is probably the most important and least understood problem of adult dentistry on natural teeth. Excellent work has been done in teaching the proper relationship of opposing cusps to each other in those patients in which the vertical dimension has been increased, but exceedingly little has been done for the more frequent and important instances in which increases are not made. Failure to establish cuspal harmony in natural teeth is responsible more than any one factor for an appalling loss of thousands of teeth that should have been saved.

SELECTION OF PATIENTS

The patients where no increase in the vertical opening is necessary can be easily handled by any dentist with his present equipment. This treatment is indicated on almost all patients from twenty to thirty-five years of age, at which ages the most lasting and beneficial results can be accomplished. Affording services for such patients stimulates and prepares the dentist to handle those patients that do require an increase in the vertical opening.

Too many are of the opinion that establishment of a balanced occlusion is a procedure employed only in those instances in which all teeth and occlusal planes are "reconstructed." Knowing that such work is highly technical, and that costs are readily met by but a small percentage of patients, dentists conclude that to master the problem would be of little benefit because of the probability that there will be practically no opportunity of employing the knowledge and technique. There is no sound basis for this attitude. When we (a) know how teeth function, (b) can recognize impediments that prevent smooth function, and (c) can reshape, through grinding and simple restorations, the working parts of the teeth (cusps, ridges, and sulci) so that all three function smoothly and distribute the stresses properly, we encourage a healthy periodontium and remove

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the factors of destruction. This treatment is not time consuming, nor does it require considerable material or expensive equipment. For these reasons, establishing cuspal harmony cannot be said to be a kind of service problem to be rendered only by those who are especially trained. As our profession comes to understand the importance of the problem and the comparative universal applicability of a sound corrective technique, more and more natural teeth will be usefully retained (as they should be) throughout longer and more useful lives. Failure to recognize discord, or improper treatment of it, in the arrangement of cusps to sulci, and sulci to cusps, lends weight to the false contentions that exist—that man's teeth are transient, that he should not expect to keep them, and that the term "permanent" teeth is a misnomer. An enlightened profession of tomorrow will not accept these viewpoints.

We, in dentistry, are charged with the responsibility of providing a service that tends toward the preservation of teeth and the maintaining of the health of the oral tissues. People want to masticate their food properly, and we want them to do this, and we should do what we can in order that they may maintain health in so far as good dentistry is concerned.

OCCLUSION DEFINED

Occlusion is a term which is so complex and broad in its scope that it is easily misunderstood by some. There is a distinction between occlusion and the simple meeting of the morsal surfaces of the teeth. For clarity, let us define occlusion as a harmonious relationship of the cusps, ridges, and fossae of the teeth in all the ranges of articulation between the upper and lower jaws, plus a harmonious relationship of the associated parts. Let us discuss the important factors of this definition.

EFFECT OF TRAUMA

The effect of trauma on the periodontal tissues was observed as early as 1860. It was then pointed out that high cusps, and out-of-line cusps, which interfere with equal distribution of stress in mastication, tend to destroy underlying bony structure.

Natural resistance, however, plays a part in upsetting our calculations. Some people withstand inconveniences, and maintain health in the face of disturbances that raise havoc with others. But that is the exception to the rule, for a very few portray enough resistance to overcome incessant traumatic occlusion. Therefore, remedial measures should be taken for all patients who have imperfect occlusions, unless we choose to encourage destruction of the periodontal tissues.

FORCES OF THE WORKING JAW

The working jaw exerts, on the average, about 180 pounds of pressure per square inch on the passive jaw. That force, exerted three thousand times a meal—three meals a day and 365 days a year—not counting swallowing nor grinding the teeth at night, is capable of causing tissue destruction unless all

parts are performing harmoniously. If we only have a few teeth doing all the work, the result most often becomes disastrous.

Certainly, it would be better to have the pressure equally distributed over all the teeth instead of being concentrated on a few, if we are to avoid periodontal diseases. It is equally true that the longer we can retain our teeth in good condition, the better chance we have of maintaining health. It is admitted that people of fifty, with good teeth, usually have good health as well. Many dentists have agreed that 60 per cent or more of periodontal diseases are caused by malocclusion. It is safe, perhaps, also to say that 80 per cent of the teeth that escape extraction because of caries in youth, are lost at the age of fifty through the ravages of periodontal diseases.

We cannot overstress the advisability of maintaining a good dentition, nor can we overlook the fact that a perfect dentition in all its parts is satisfactory for use only when those parts are adjusted to the work to be performed. We are an omnivorous type of animal, using some of the grinding movements of the herbivorous and some of the cutting movements of the carnivorous animals. We, therefore, must incorporate in our work what nature needs, i.e., a functioning centric, a right and left lateral, and an incisal or protrusive relationship. McLean[1] stated this part of the problem clearly and concisely when he wrote: "The mandibular teeth are swept across the maxillary teeth. The smooth and efficient interplay of the cusps and fossae of the mandibular teeth with those of the maxillary teeth will depend upon two things—whether the teeth are in positions harmonious to the dynamic centers of movement, and whether the position, height, and angulation of the cusps and fossae are in harmony with the arcs through which the mandibular teeth move; smoothly functioning teeth are subject to what we may term legitimate stress."

THE INTERPLAY OF CUSPS AND FOSSAE

This is an excellent statement of the working dentition as a whole, which in effect admonishes those who would work well to *establish* this smoothness in the functioning teeth, and through this provide that all the teeth be subjected to the legitimate stresses of mastication, but no more. The most perfect relations are attained when the arrangement of the teeth permits the morsal surfaces of all the bicuspids and molars to be in occlusal contact simultaneously in lateral relation. The transverse ridges of upper first molars play an important part in influencing the direction with which teeth slide over each other. When the upper and lower arches are brought together in centric occlusion, the anteroposterior curve, or curve of Spee, and the right and left lateral curves become identical (Figs. 1 and 2).

Wheeler[2] states, "The long axes of the upper and lower opposing teeth are in the form of an arc—known as the axis curvature."

In this it is shown that the whole scheme of teeth and jaws is in arch form—movements and arrangements of the teeth, jaws, and condyle all conform to an arc of a curve. These can harmonize with muscles, ligaments, and condyle seat (Fig. 3).

The curve of Spee—the front teeth and inclined planes of the posterior teeth,

assisted by the muscles and ligaments, hold the jaws in the right position. It is most convenient to hold them there if all are in harmony. The condyle allows the mandible to swing where the most efficiency is possible—provided there is not

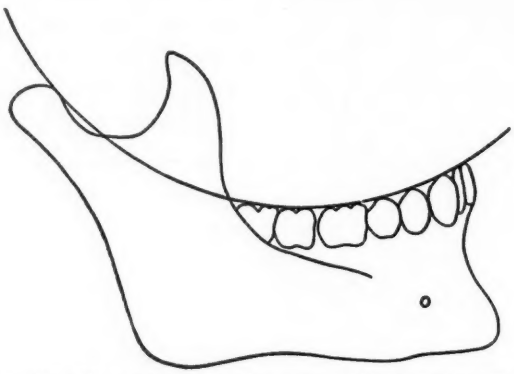

Fig. 1.—Diagram illustrating the anteroposterior curve—the compensating curve, or the curve of Spee (Wheeler).[2]

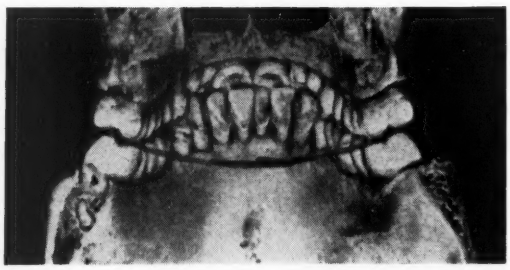

Fig. 2.—The lateral curve (after Prothero).[9]

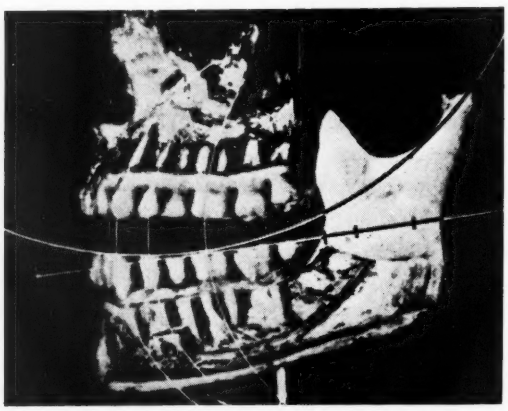

Fig. 3.—The axial curvature (Wheeler).[2]

any interference. But with interference, the mandible will be moved to a more convenient relationship—a position where the food can still be masticated with nature's now handicapped teeth. Patients accommodate themselves to weak or

lame spots by shifting positions to ease physiologic embarrassment. In their attempts to masticate to advantage, they bring on disturbances elsewhere. In aggravated cases, centric occlusion is shifted and then, dentally speaking, the end is not far off. We cannot reduce muscle strength or change their actions, nor can we reform nervous energy. But we can, instead, prepare the occlusal surfaces of teeth to distribute the stress.

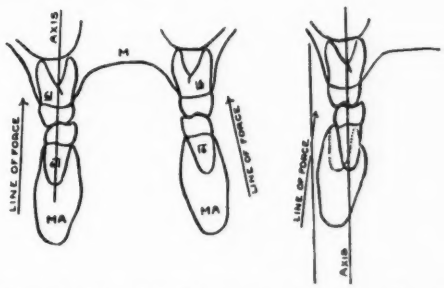

Fig. 4.—*A*, (left) Outline of a cross-section through the maxilla and mandible at the site of first molars. The line of force exerted when the teeth come into contact should be parallel to the long axis of the teeth. If the teeth are in the proper position to withstand this force, their positions will be stable (Wheeler).[2] *B*, (right) A drawing showing the first mandibular molar out of normal position. Its axis is not parallel with the line of force, and consequently the act of mastication would tend to unseat the tooth (Wheeler).[2]

DIRECTION OF STRESSES

Tylman[3] states, that "Since alveolar bone responds most favorably to tension, it may be safely stated that stress parallel to the long axis of the tooth is the most favorable direction in which a tooth may be moved—and that the bulk of the periodontal fibers is of the oblique group which primarily resists a vertical stress, it is evident that nature has responded to the physical demands, through the biologic design of its periodontal membrane. Nature possesses such powers of compensation and adaptability that in the course of a few years new forces are gradually balanced." (Fig. 4). Tylman then points out that this is true only if the new forces are not traumatic, or beyond the physiologic limits of tissue adjustment.

The ability to readapt to new conditions is lessened as the patient grows older. In youth the tissues are highly vascular, a condition which affords the maximum resistance to infection and ability to build strongly; conversely, age brings denseness, less blood supply, and less resistance to infection. Due to habit, diet, and marriages of people of different racial characteristics, the teeth of offspring may assume peculiar deformities. They by no means always approach the norm as set up by the profession, but is it not our duty to try and bring about that ideal condition?

RARITY OF GOOD NATURAL DENTITIONS

We all agree that good natural dentitions are rare—many men who have studied occlusion for years have seen only a few cases which they regarded as approaching the norm. Very few of the skulls in our museums of natural history are of

value in the study of occlusion, due to the above conditions. In looking over Eskimos' teeth, we see that through severe masticatory functioning, the teeth are ground into harmony and that they possess well developed investment tissues. This is nature's positive evidence in support of the contention that teeth should be ground and restored so they will wear uniformly with equal stress throughout. Periodontoclasia is nature's negative evidence in support of the same doctrine.

SPECIALISTS RECOGNIZE IMPORTANCE OF BALANCED OCCLUSION

Prosthodontists have the picture and are now directing their attention toward balanced occlusion. The periodontists have known for years that one of the most effective treatments for periodontal diseases is through establishment of cuspal harmony. The orthodontists, after spending years arranging teeth for esthetics, are now directing their energies toward attaining balanced occlusion for their patients.

Why are these categories of specialists giving painstaking efforts to the principles of balanced occlusion? Because they are duty bound to give their patients a dentition that will function properly, look well, and convert harmful into beneficial stresses. If such groups incorporate in their techniques the efficiency and preservative effects of balancing occlusion, why shouldn't we exercise the same precaution on the great mass of people instead of just filling cavities and inserting bridges? There is no good reason why our patients should not retain their teeth longer than they do. And they should if we follow through on these responsibilities. Fully 90 per cent of the people of the age of twenty and over, with natural teeth, would be benefited by being afforded occlusal adjustments, and many of these require only comparatively minor changes. Very few people have satisfactory cuspal harmony in the lateral ranges. In those patients where no increase in the vertical opening is necessary, merely the grinding of a few high cusps and the building of others is all that is needed to obtain cuspal harmony. Do this at twenty to save the teeth at forty. Between sixteen and nineteen years of age, the final forward and downward growth of the face occurs. Therefore, we should start our work at twenty, after the orthodontist thinks it advisable to discontinue his work, while the investment tissues are normal and the vertical height is satisfactory.

THE ORTHODONTIST'S AIM

Speaking of orthodontics, that science has for its object the correction of the malocclusion of the teeth. Orthodontists still have much to do in order to adjust the long axes of the teeth to harmonize with the best bony reinforcement, and to bring the lingual cusps of the lower posterior teeth up to contact with the lingual cusps of the uppers, on the working side in the lateral occlusion positions (Fig. 5).

When the teeth are in lateral occlusion on the working side, the buccal and lingual cusps of the lower are laterally in line with the buccal and lingual cusps

of the upper (Fig. 6). The fossae of the opposed morsal surfaces form a groove in which the food is crushed by the mandible sliding toward, and sometimes through, centric occlusion toward the opposite lateral position. The sliding movement crushes food more efficiently and with less pressure than when a chopping movement is employed. The chopping masticatory effort is nearly always employed if the teeth are not harmoniously adjusted. Tylman selected "extreme

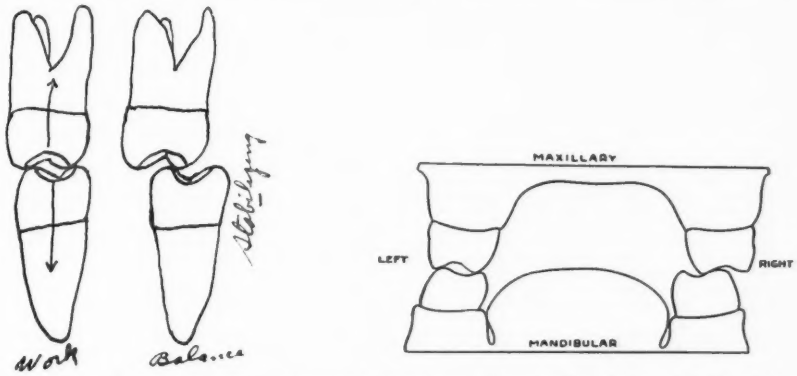

Fig. 5.—In the lateral ranges: schematic drawings of posterior views of first molars in left lateral occlusion. The left molars are "working," the right molars are serving as balancing contacts. Note the cusp relations and the escapements that are provided (Wheeler).[2]

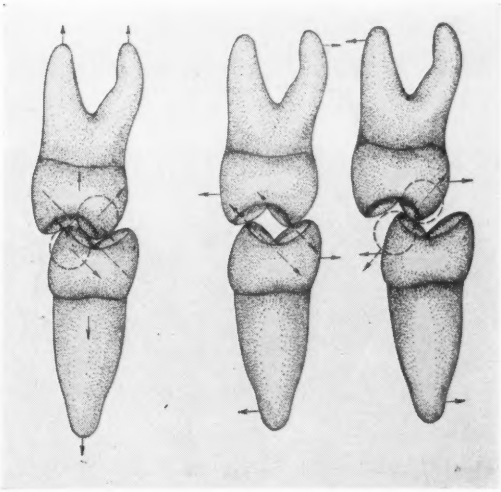

Fig. 6.—Centric, working, and balancing positions (Tylman).[3]

lateral occlusion to demonstrate the action of trauma" and then pointed out that "the right angle gives an opportunity to exert more force than when applied to a more acute angle." It follows from this that there is less force applied laterally on well defined cusps than there is on poorly defined cusps, and that, therefore, flat occlusal surfaces must be altered (Fig. 7).

Most people with natural teeth have correct centric relation and occlusion because the teeth of the upper and lower jaws have a tendency to elongate until their morsal surfaces meet to oppose each other.

By fourteen years of age, twenty-eight teeth are in apposition. As the width of the palate increases and the arch widens, the upper first molar advances to the best available buttress of reinforcement, which is under the zygomatic process. The widening of the arches tends to place the teeth in a position so the lingual cusps of the upper and lower are elongated to be in a position to play their part in balance and work position in the lateral occlusal ranges (Fig. 8).

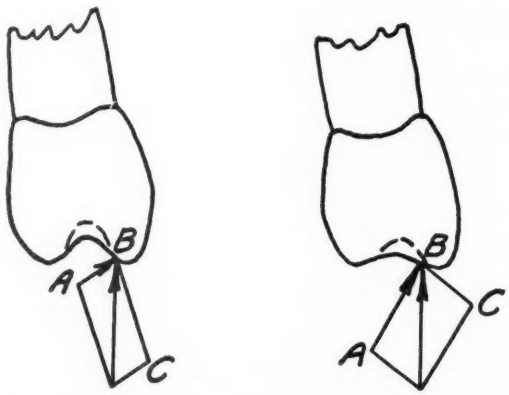

Fig. 7.—Flat cusps should be altered. "Stress applied to a right angle. The more acute the angle, the less applied stress laterally." (Tylman, after Maxwell.)[5]

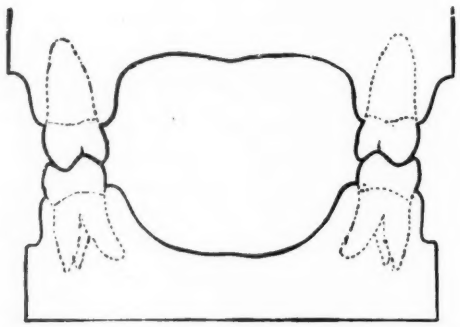

Fig. 8.—Diagram illustrating centric occlusion in the molar region (Prothero).[9]

ATKINSON'S INVESTIGATIONS

Contrary to general belief (that if lines were drawn through the long axes of the teeth the lines would meet in a common center somewhere above the top of the cranium), Atkinson's[4] investigations show that (1) the whole tooth is moved laterally; (2) the long axes of the teeth point not toward a common center, but toward the best bony reinforcement; and (3) the long axes of the uppers on the right and left sides are parallel (Fig. 4).

The greatest stress in mastication is exerted in centric occlusion but this is counterbalanced by having all teeth in contact. For each tooth (except lower centrals and upper third molars) opposes two other teeth, and each tooth, except

wisdom teeth, is supported by two adjacent teeth (Figs. 9 and 10). Just like the old saying, "All roads lead to Rome," all strokes of the mandible lead to or through centric occlusion.

In positions other than centric, the maximum force is exerted in the work position with far less on the balancing side (a stabilizing effect). In protrusive position, less force is exerted because the posterior fibers of temporal muscles do not operate in this position. In true protrusive balance, all teeth come in contact through the buccal and lingual cusps of the posterior teeth and incisal edges of anterior teeth.

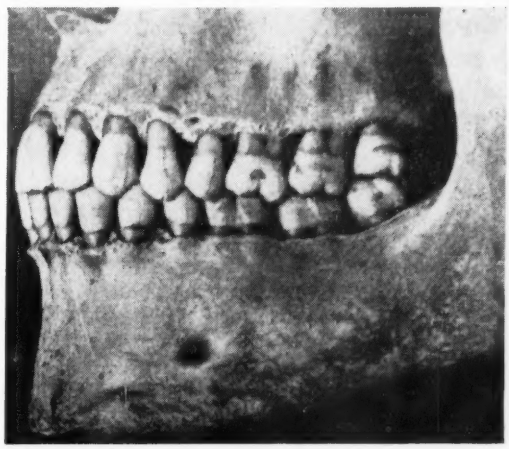

Fig. 9.—Facial aspect of centric occlusion (Wheeler).[2]

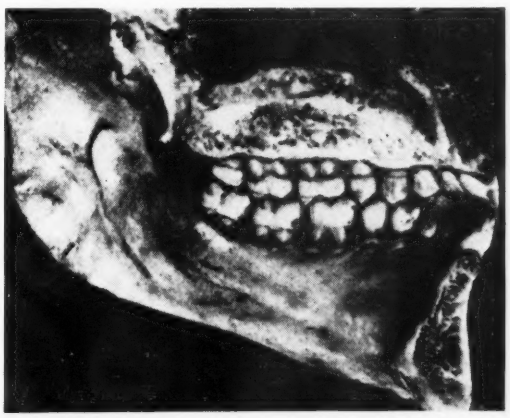

Fig. 10.—Lingual aspect of centric occlusion (Wheeler).[2]

TOOTH-CONDYLE RELATIONSHIP

The size of the teeth is predetermined, and is not influenced by function or the part that function plays in the development of the bones and muscles. The height of the cusps is also predetermined, but in many people is reshaped through masticatory function. The height and shapes of the cusps of the teeth play a

big part in molding the condyle and its path, and as the cusps change, so does the condyle. Widen[5] reported that there was 4/32 inch between centric occlusion and the rest position in 87 per cent of two hundred patients investigated, and that when the teeth wore down and the vertical opening closed, there was still 4/32 inch difference in these two positions, showing that the condyle adjusted itself to the lower vertical position of the mandible. The same conditions prevail, i.e., a remodeling of the shape of the condyle in re-establishing the vertical opening to its original position. In every direction, inclined planes or arcs either open or allow the teeth to return to or through centric. Each tooth should play its part in distributing stress. The condyle allows these movements over arcs and planes, as it accommodates a multiplicity of movements and the muscles exert their forces, while ligaments control stability, aided by the balance on the balancing side in lateral occlusion.

Fig. 11.—Vertical stresses in centric position.

RESULTS OF CORRECTION

When all cusps have been properly ground or built to their maximum physiologic efficiency to form the upper and lower occlusal planes, the following conditions prevail:

1. Proper function in the mouth in all mandibular positions.
2. Maximum number of opposing teeth in contact in all positions.
3. Teeth have maximum crushing and shearing powers.
4. Mastication is carried on with less pressure, and stresses are exerted more nearly through the long axes of the teeth (Fig. 11).
5. The investing tissues are best able to withstand and absorb stresses.

A consideration of many articles concerning occlusion, the condyle, glenoid fossae, ligaments, muscles of mastication, and position of the cusps in occlusion in

all the various ranges, indicates that the consensus is that the ideal is seldom found. One is reminded of Diogenes with the lantern looking for an honest man. But in dentistry we have conditions easily adjustable to the ideal constantly before us. We must be aware of our opportunities to produce needed harmony from conditions as we find them. If there is—and there must be—a simple method of producing harmony in the lateral ranges with whatever we have to work with, more and more of us must adopt it if we are to justify ourselves as dentists. We can, by grinding, restoring, and replacing, bring most of the teeth from the cuspids to the second molars (buccal and lingual cusps) into harmony, that is, so that each tooth carries part of the stress in centric and lateral ranges and has that stress applied along its long axis, regardless of whether the axis is in the ideal anatomic relationship or not.

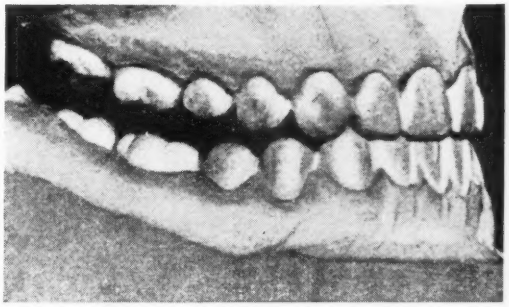

Fig. 12.—Abnormal increase in the vertical opening. Note the amount of restoration required on the posterior teeth, if an attempt is made to restore occlusal balance (Johnson).[10]

HOW FAR SHOULD WE GO?

With the advancement of orthodontics and public education, teeth will be placed in the ideal positions, such as the adjustment of the long axis in line with the proper reinforcements of bone, with cuspal harmony for distribution of stress. We can produce working and balancing contacts on the posterior teeth, but due to the vertical overlap on many mouths, it is impossible to produce incisal balance without increasing the vertical relationship through extensive "reconstruction" of the posterior teeth (Fig. 12). There has been much criticism directed toward some of our vertical opening attempts. The "conservatives" believe it unwise to increase the occlusal vertical dimension beyond the original opening that nature provided, because, they argue, the muscles, bones, ligaments, blood vessels, and nerves cannot be successfully changed to an arbitrary position.

I feel that radical adjustment of the incisal balance is seldom advisable, due to the vertical overlap; but right and left lateral balances can be developed in most mouths. Since 90 per cent of mastication is accomplished on the posterior teeth, we need only to produce work and balance on these teeth in order to distribute and direct the stress along the long axes of the teeth. However, increasing the vertical dimension of occlusion is far better than is the objectionable practice of constructing appliances to decrease the vertical dimension of occlusion, thus permitting deformities to continue and inviting new ones to develop. We

should fill, replace, restore, and balance, for most mouths need all four. A few, through education, will appreciate your efforts, accept your services, and help you raise the standards of dentistry.

METHODS OF RECONSTRUCTION

There are five distinct methods of reconstruction. They are: (1) the control crown method, (2) the plate method,[6] (3) the splint method, (4) the balance occlusal guide method,[7] and (5) McCollum's method.[8]

Each has been described in the literature with the possible exception of the control crown method. Opinions differ as to the relative merits of the various methods. To condition your opinion, consult men who use one or another of these methods. But be careful about increasing the vertical dimension of occlusion beyond the original position, and see to it that the lingual surfaces of the cuspids take care of the lateral thrust along with the inclined planes of the posterior teeth. Balancing and working contacts must be worked in to overcome increased leverage.

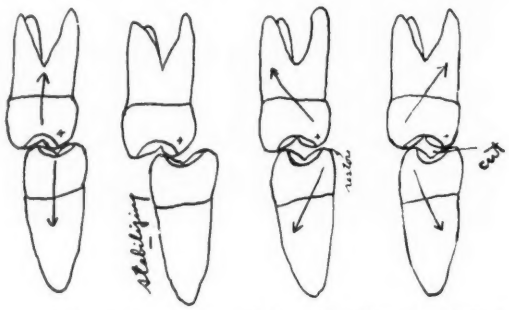

Fig. 13.—Note the upper lingual cusp (on left), and follow it through and determine why, if it is right, the lower lingual cusp must be restored or cut off.

CONTROL CROWN METHOD

From casts mounted on an anatomic articulator, one can study the occlusal surfaces of the teeth and estimate very closely the amount of wear that has taken place. If the cuspids are in line, we can estimate the wear there. Cuspids are the guides to how much to increase the vertical dimension of occlusion in most cases. Build the cuspids up in wax to their original height, then in turn build up the posterior teeth, and bring into play all your knowledge of alignment, curve of Spee, and esthetics. Then apply the rule, which is nearly entirely responsible for the article—*"If a cusp is right in two positions, it is right."*

This rule applies to centric and lateral ranges (Figs. 13, 14, 15). Either build up or cut down a cusp that interferes or does not touch. If you use the control crown method, after you have adjusted the interfering cusps, return the controls to the mouth and prepare the four to six teeth that will control the vertical dimension when it is increased the required amount. These controls are, obviously, the four cuspids, or the two upper molars and the two lower molars that will oppose each other on both sides of the mouth. Make impressions and check the centric relation, insert the dies, articulate and carve the crowns as accurately as possible. Cast the crowns, return them to the mouth and refine them until they

function in right and left lateral and centric positions. Use the mouth as the final articulator. If a cusp is too high, trim it down; if it is too short, restore its height until it makes contact in all ranges. This step is proved, and in case of an error merely return to this stage. Prepare the other teeth, make the impressions, check the jaw relations, insert the dies, occlude and carve the restorations using the refined abutments as checks against the articulator. Cast the restorations, insert them in the mouth and refine them as before. Repeat this for each step, always using the rule.

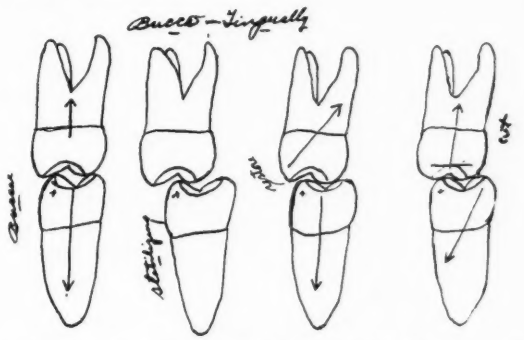

Fig. 14.—Lateral ranges. Note diagram: (1) at the left—The upper and lower molars are in working position, and the buccal and lingual cusps touch simultaneously. Thus, stress is directed through the long axes of the teeth as indicated by the arrows. Note the cross on the lower buccal cusp and follow that cusp to the next diagram. (2) The cusp is in a balancing position. Follow the same cusp to the next diagram (3), and note that the teeth are in centric position but the lower buccal cusp does not touch. Since that cusp was right in working and balancing positions, we must assume it is correct, although it does not touch in centric position. Therefore, we must restore the sulcus of the upper molar until it touches the lower buccal cusp. Then we have contact in all positions. If, as shown in the next diagram (4), the lower buccal cusp touches first, we must deepen the sulcus of the upper molar in order to have harmony in all positions in the lateral ranges, because the lower buccal cusp was right in working and balancing positions in the first two diagrams. Note the direction of stress as shown by the arrows.

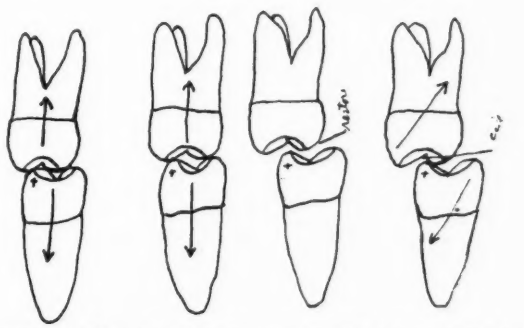

Fig. 15.—Lateral ranges. The first diagram on the left shows centric occlusion with stress along the long axes of the teeth. Follow the lower buccal cusp with the cross to the next diagram (2), where it is in working position with stress applied along the long axes of the teeth. Follow to the next diagram (3), and note that the lower buccal cusp (with cross) does not touch in balancing position. Since the lower buccal cusp touched in centric and working positions, it must not be restored, but the upper lingual cusp must be restored to touch the lower buccal cusp in order to make contact in all positions in the lateral ranges. Note in the next diagram (4), that the lower buccal cusp touches too much, but since it was right in centric and working positions, it is right. So, in order to produce harmony, the upper lingual cusp must be reduced (ground off) so it touches at the same time as the teeth in the working position do on the other side of the mouth. The lower buccal cusp must not be modified.

THE IMPORTANCE OF AGE

A large number of the cases for complete reconstruction are due to early neglect. Why wait until the far end of life, when destruction and diseases have developed and the success of our work is in doubt? Instead, let us start early while the vertical height is right and the investing tissues are normal. At twenty years of age we can prevent untold harm and develop a field of service that is to accomplish much for those for whom it is provided.

There are patients for whom it is not necessary to increase the vertical opening. There has been considerable criticism of spot grinding and milling. When it was first introduced, many thought it was the panacea and started grinding teeth to allay all cuspal discord. But the sad part of it was that only the buccal cusps were observed, and if a malocclusion existed, the milling decreased the occlusal vertical dimension and the teeth were still out of balance. The lingual cusps and the loss of centric relation were not considered. There again, a good repair job was ruined by stopping too soon. Then the inclined planes of the

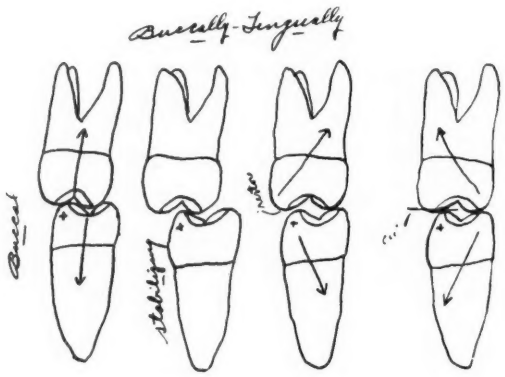

Fig. 16.—Note the lower buccal cusp (with the cross) and follow it through, noting the direction of stress as shown by arrows, and determine why it must not be restored or ground off. The upper buccal cusp must be restored or ground off to have contact in all positions in the lateral ranges.

buccal and lingual cusps were ground, taking an equal amount off the upper and lower cusps here and there in an attempt to maintain a functioning centric occlusion. Working and balancing contacts were overlooked, as well as the direction of stress along the long axes of the teeth; and the fact that the reduced surfaces due to natural wear would reduce the vertical height rather rapidly was forgotten. Buccal cusps were ground which helped, but no attention was paid to the lingual cusps in working positions. We must pay attention to the lingual cusps to stop the tipping action and to direct the stress along the long axes of the teeth. My attempt here is to give you a rule by which you can tell just which cusps and sulci to grind, and which cusps or sulci to build up, in order to have the maximum contact on the occlusal surfaces in all ranges of centric and lateral occlusion.

THE RULE OF CUSPAL HARMONY

The rule is: "If a cusp is right in two positions it is right." Following this rule, any cusp that interferes with or does not occlude with *another cusp that is right* must be altered. It must be either built up or ground off to harmonize with the cusp that is right (Fig. 16).

In centric and the lateral ranges, the upper lingual cusps and the lower buccal cusps of the posterior teeth have three positions, namely, centric, working, and balancing; while the upper buccal cusps and the lower lingual cusps have two positions, namely, centric and working. Make an accurate impression of the upper and lower jaws. Make a maxillomandibular record and use the face-bow to mount the casts on an anatomic articulator, then adjust the instrument and study the occlusion. You seldom see an occlusion that does not need correction.

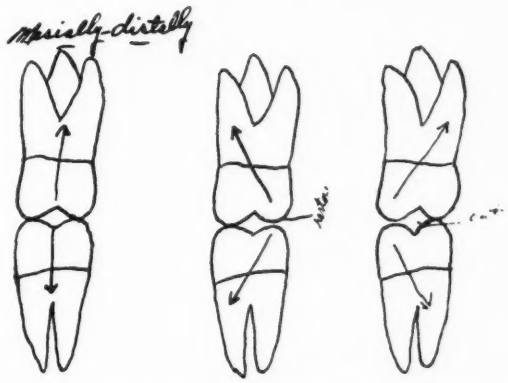

Fig. 17.—When the four buccal cusps strike simultaneously, tipping action on the teeth is prevented, and the stress is applied through the long axes of the teeth, provided the lingual cusps also touch. Any cusps that prevent this must be altered—either restored or ground off. This applies to the development of incisal balance.

Now, where will we start to grind? From centric position move the casts into right or left lateral position. First, note the interfering cusps, then adjust them according to the rule. If a cusp is right in centric and balancing positions, and interferes in working position, it must not be altered, but he cusp that opposes it must be cut down or built up. If the cusp is right in the working and balancing positions, and interferes in centric position, it must not be altered, but the accommodating sulcus must be deepened.

If the sulcus does not touch after you have altered a cusp, you must build up the sulcus, for a continuous full contact must be maintained on all ridges and cusps in fixed positions and paths. If the lingual or buccal cusps touch first, a continuous tipping stress that absorbs the underlying bony structure exists. Likewise, if the mesial or distal cusps touch first (they must touch simultaneously), a constant tipping mesially or distally is produced, which causes absorption of the underlying bone structure (Fig. 17).

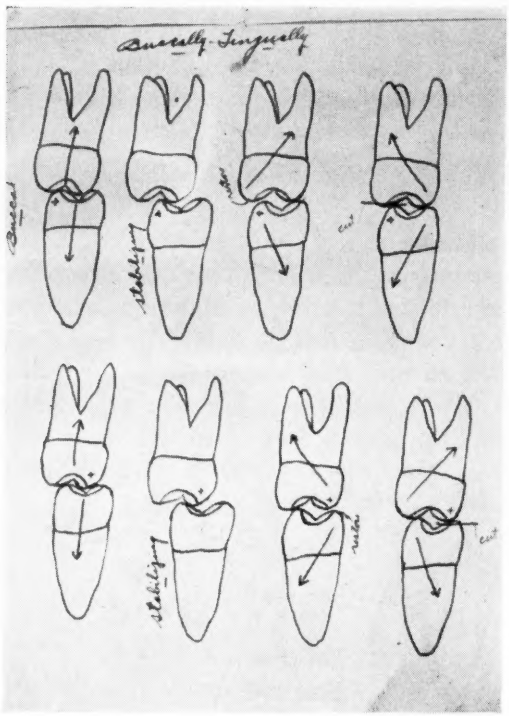

Fig. 18.—Follow cusps marked with crosses through the various ranges to prove the rule, "if a cusp is right in two positions, it is right."

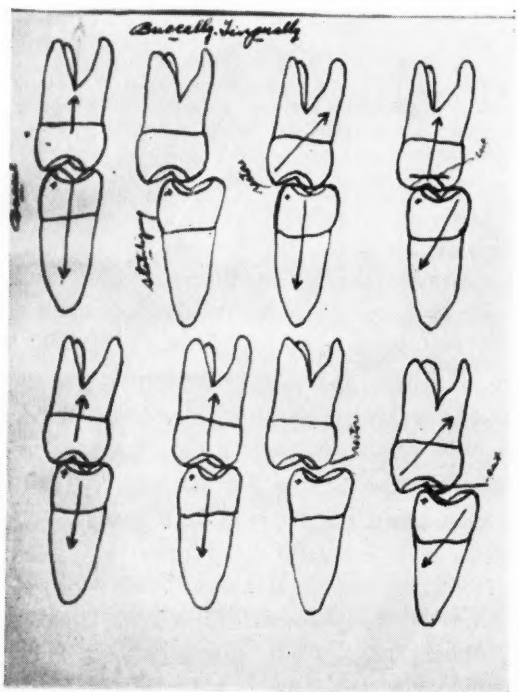

Fig. 19.—Follow cusps marked with crosses through the various ranges to prove the rule, "if a cusp is right in two positions, it is right."

SPOT GRINDING

Grind each cusp by spot grinding on the articulator. (Never mill the occlusion on the casts, because milling reduces the cusps that are right as well as those that are wrong.) Pencil the altered cusps to help you as corresponding modifications are made in the mouth. After grinding, use another set of casts to note the short cusps and low sulci (apply the rule). Restore these cusps and sulci to their correct functional forms with wax (Fig. 18). Then move the casts on the articulator through the various positions and note the harmony and function of the entire dentition. The occlusion will have a series of irregular cutting convex ridges, which will operate smoothly with the least energy and greatest efficiency. Then restore these same cusps and sulci of the teeth in the mouth. Some mouths need two, four, or six cusps and sulci restored to produce centric, working, and balancing contacts after the spot grinding is completed. Natural teeth cannot be *ground* into occlusion. The establishment of a satisfactory cuspal relationship requires *both* grinding and building up. Building cusps and sulci seems to imply cutting tooth structure, but this is seldom necessary because so many of the teeth requiring this work have been previously restored in part with fillings, in which event no tooth structure is sacrificed. Use carbon paper and have the patient close in working, or balancing, or centric position, and note the carbon markings. Then apply the rule and alter the cusp that is not right in two positions (Fig. 19). If a cusp is right in the balancing and working positions after altering, and it interferes in centric position, deepen the opposing sulcus. Esthetics and alignment will help guide you, for it is not desirable to build a cusp so long that it is out of line and looks unsightly. Build the others, and apply the rule and adjust the sulci and other cusps to keep the alignment and enhance the esthetics.

SUMMARY AND COMMENT

We assume that all dentists can prepare a cavity, make inlays and crowns, and with a little observation adjust the occlusal surfaces to harmony, as these are the only things we have an opportunity to improve upon. All other factors are outside of our control and there is nothing that we can do to alter them. By adopting this premise, we have a starting point from which to bring into use all our knowledge on something we now know should and can be done. Let us make the best of what we have to do with. We must muster all the technique available and apply it to the patient being treated. People will live regardless of faulty occlusion, but not nearly as well nor probably as long. The dental apparatus (as other bodily arrangements) may be compared to a railroad train and track. If the track is smooth, it determines the direction of the train, which floats along smoothly, exerting all the power it can up to the limit of the roadbed to withstand. But let a flat wheel or an irregular rail develop, and the traumatic effect soon destroys the roadbed. We can remove trauma by harmonizing the cusps and sulci, thus equalizing the stress and directing it along the long axes of the teeth.

Clinical examinations and articulated study casts are the methods by which discrepancies are revealed. The roentgenograms will disclose the conditions of the investment tissue, and reveal incipient stages of tooth destruction. Some cases require real engineering feats, but many of the complicated ones could have been prevented if they were treated early in life. We must look into occlusion so we can complete the picture, or at least attempt to educate our patients to appreciate what dentistry offers. You will convince a few, and they in turn will educate others and eventually more and more people will become enlightened. Our past efforts have been directed principally along the lines of improved esthetics and mechanical perfection, while the intended purpose of teeth has been overlooked. Not all of us have incorporated a consideration for function in our work.

The day is coming when patients will demand better cuspal harmony. Will we be prepared to meet that challenge? I have complete confidence that we will and that, with an awakened consciousness of the need, we will, through study and experimentation, bring into use many original ideas that will make the achievement of cuspal harmony seem simple.

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COMPARISON OF BALANCED AND NONBALANCED OCCLUSION OF ARTIFICIAL DENTURES BASED UPON DISTRIBUTION OF MASTICATORY FORCE

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THE INFLUENCE OF BALANCED versus nonbalanced occlusion of artificial teeth on the success of complete denture service has provoked some of the most controversial thinking recorded in the field of prosthodontics. The opinions, theories, and conclusions generally expressed are based upon such factors as: clinical observation, condylar paths, geometric patterns, articulator movements, functional strokes, nonfunctional glides, masticatory performance, and tissue tolerance. The effect of the bolus of food has been given some consideration, although frequently attention has been limited to various contact relations of opposing occlusal surfaces, or to the movement of the surfaces upon one another.

If one "believes" in balanced occlusion, he may be satisfied with three-point contact, or may seek contact of all opposing cuspal inclines and incisal edges in lateral and protrusive excursions. These multiple contacts, widely spread throughout the arch, are claimed to distribute the forces of mastication most favorably, preserve the ridges, aid in stabilizing the dentures, and ensure maximum comfort to the patient. The objectives of balanced occlusion are sought either through the use of anatomic types of teeth, or by employing inclined ramps behind the last molars. On the other hand, those who feel that balance is unnecessary or ineffective in function, strive for denture stability through altered tooth forms, highly favorable tooth-to-ridge relations, use of the reverse curve, reduced food table, or modified chewing habits.

Although countless articles have been written on the subject of occlusion, a comprehensive review of the literature failed to reveal any studies which compared the stability of dentures with balanced and nonbalanced occlusions in function. It was felt, therefore, that investigations conducted along this line during the actual mastication of food would be of value in determining the extent to which balanced occlusion could be expected to augment the stability of complete dentures.

TESTING PROCEDURES

Electronic equipment and sectional dentures used by the author in previous studies[1] provided the means for measuring forces delivered to the tissues by an upper denture during chewing. The same setup was used for the present study,

The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

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in the hope that an evaluation of denture stability could be made through a comparison of force distribution with the balanced and nonbalanced dentures.

SR-4 type strain gauges were secured to six isolated areas of the upper denture base on a line projected between the first molars. These areas were located in the buccal flange, ridge crest, and palatal slope of each side (Fig. 1). The gauges were connected to Wheatstone bridge circuits with suitable amplifiers and oscillographs to record the deflections produced by the pressure of the denture against the tissues. Conversion graphs were used, subsequently, to determine the magnitude of the forces imparted at each area to which a strain gauge was attached.

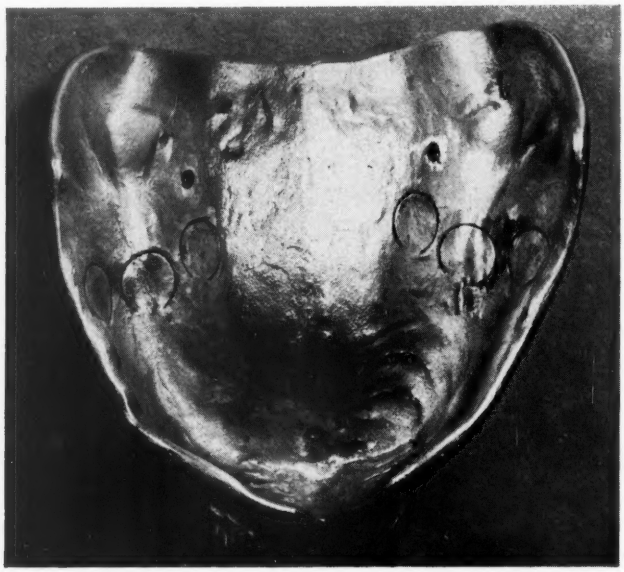


Fig. 1.—The location of testing islands and manner of their isolation.

Denture sections which employed 30° Pilkington-Turner posterior teeth (Fig. 2) were attached to the upper and lower cast metal bases. The guiding inclines of the teeth were balanced carefully to harmonize with the patient's condylar paths and the desired incisal guidances. The incisal guide table was elevated posteriorly and laterally so that steep cuspal inclines could be maintained, thus creating a pronounced rise in lateral and protrusive excursions (Fig. 3). It was felt that the presence of an accentuated rise would develop relatively large horizontal components of the chewing forces and magnify any tendency toward instability of the dentures. This situation was intended to provide the problem from which the benefits of a well-balanced occlusion could be evaluated.

Studies made previously showed that greater pressure was exerted during the mastication of peanuts than during the chewing of carrots or tender roast beef, peanuts were selected for use in these tests. Three-gram portions of jumbo salted peanuts were chewed thirty strokes for each recording (Fig. 4). This procedure was followed to produce five records of bilateral chewing, and was repeated for unilateral chewing on the left and unilateral chewing on the right. The entire procedure was carried out on three consecutive days to give a total of fifteen records of each type of chewing with the teeth in balanced occlusion.

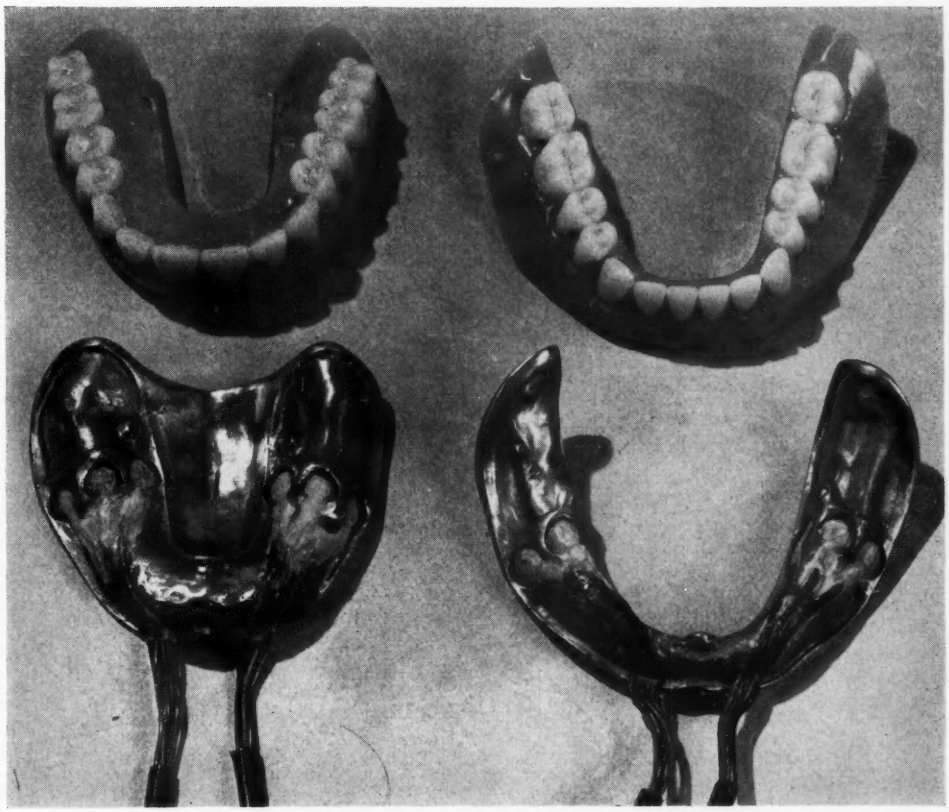


Fig. 2.—The cast metal bases and removable denture sections. Strain gauges have been attached to the testing islands.

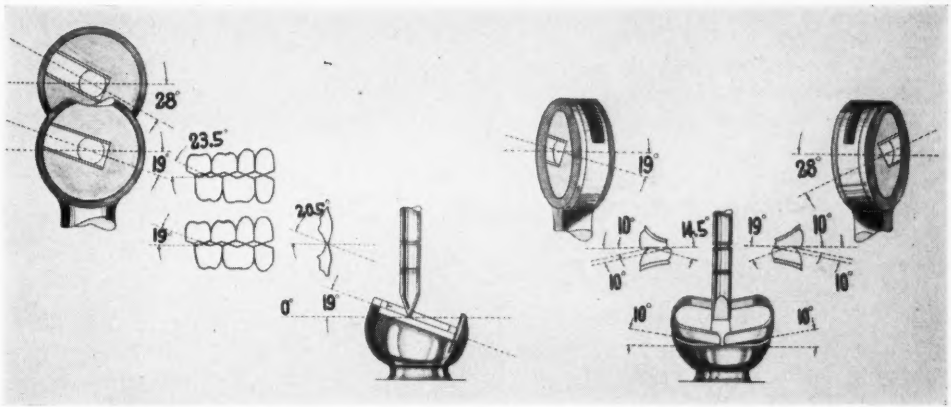


Fig. 3.—Elevation of the incisal guide table allowed steep cuspal inclines to be maintained in harmony with condylar paths

Upon completion of the recordings with the dentition in balanced occlusion, the dentures were returned to the articulator for reduction of certain cuspal inclines to produce a nonbalanced occlusion. The right side was selected as the nonworking side for modification because of the patient's preference for the left when unilateral chewing was directed. Centric occlusal contact was maintained, but the balancing inclines of the buccal cusps of the lower right posterior teeth were reduced to create a clearance of approximately 1 mm. between the upper and lower teeth at the end of the lateral glide to the left (Fig. 5). Then the dentures were carried back to the patient for repetition of the chewing and recording procedures which had been conducted with the teeth in balance.

Fig. 4.—Tracings from six areas of the upper denture. Positive pressure is indicated in all areas. Reversal of the peaks in channels *1*, *3*, and *6*, is due to reversed wiring of the circuits and not to negative responses from the strain gauges.

PRESSURE REGISTRATION AND DENTURE STABILITY

There was evidence, with both unilateral and bilateral chewing, that positive pressure was not present at all locations during all chewing strokes. The recordings indicated that there was either absence of pressure, or actual negative pressure, in certain areas in numerous instances. This was shown by reversal of the peaks in the recordings, and by tracings which were so erratic that they could not be in-

terpreted as being either positive or negative. Typical negative responses from the area of the right ridge crest during unilateral chewing on the left side are contrasted in Fig. 6 with records of heavy positive pressure from the same area when unilateral chewing was shifted to the right side. A typical fluttering type of tracing, which does not indicate either positive or negative pressure, was obtained from the left buccal flange of the balanced denture during the final strokes of a bilateral chewing series. This tracing is compared in Fig. 7 with a positive pressure recording from the same area during unilateral chewing on the left.

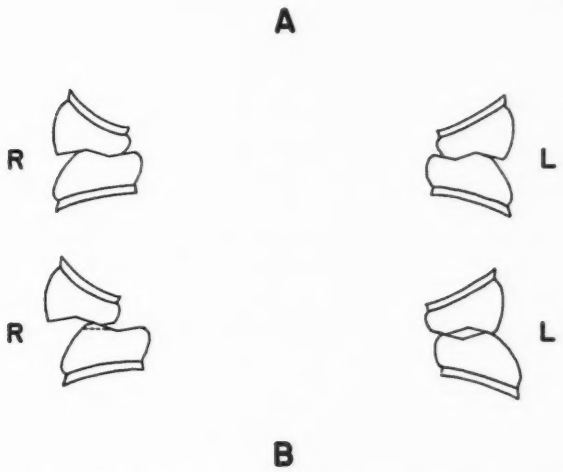


Fig. 5.—*A*, Schematic illustration of tooth and cusp incline relations in centric occlusion. *B*, Tooth and cusp incline relations at end of lateral glide to the left side. The dotted line on the lower right molar indicates the area reduced to create nonbalanced occlusion.

The absence of positive pressure recordings indicated that there was only static contact, or loss of intimate contact between the denture and the tissues during chewing. The condition occurred with both the balanced and nonbalanced dentures and was observed most often in the left buccal area during bilateral chewing, and at the ridge crest of the nonworking side during unilateral chewing on either side. It was interesting to note that when the patient was directed to chew unilaterally he was frequently conscious of the denture's loss of contact with the tissues on the nonworking side. He stated that there was a sensation on the nonworking side "like the sloshing of a foot in a wet boot." Whenever he was aware of this sensation, there was appreciable decrease in both the pressure and number of chewing strokes showing positive pressure at the ridge crest of the nonworking side. In spite of the loss of contact with the tissue, the denture seal was never broken; atmospheric pressure and the fluid film beneath the denture apparently offered sufficient resistance against tipping forces to maintain stability of the denture.

PREMISE

It was assumed that an indication of the value of balanced occlusion in augmenting denture stability could be interpreted from the recordings as follows:

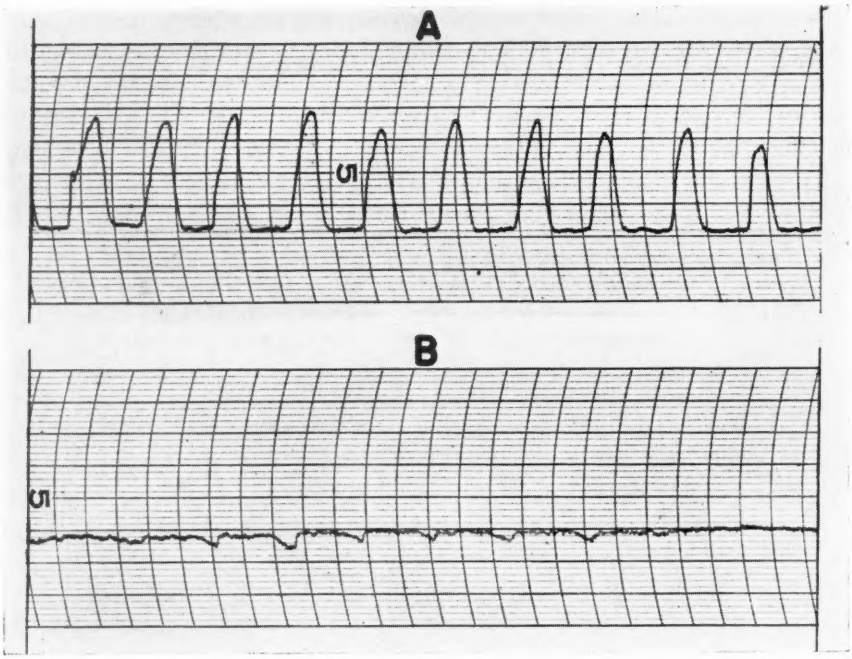


Fig. 6.—*A*, Tracing showing positive pressure from area of right ridge crest during unilateral chewing on the right side with the balanced denture. *B*, Tracing indicating negative pressure when unilateral chewing was shifted to the right side.

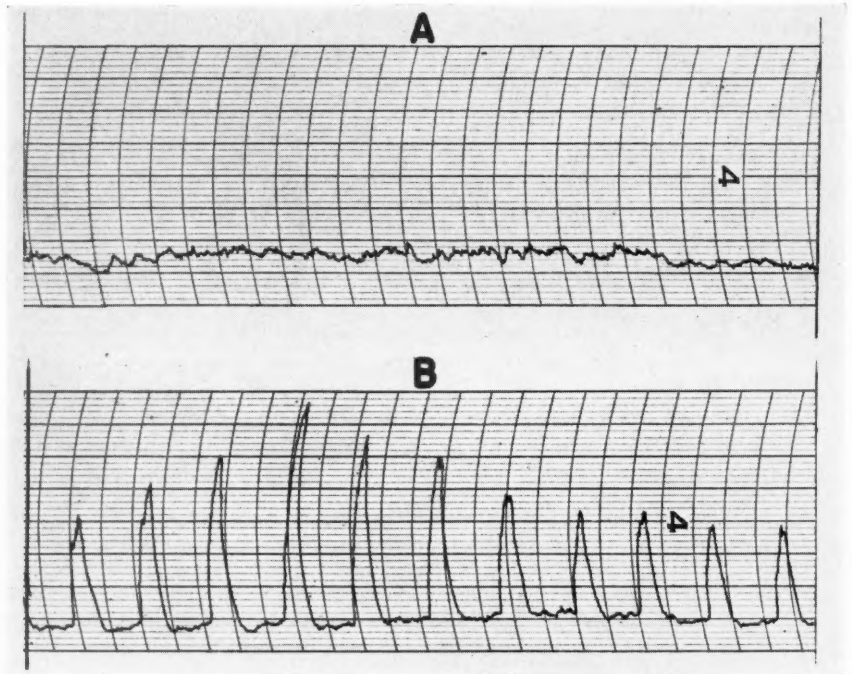


Fig. 7.—*A*, Tracing obtained from the left buccal flange during the final strokes of a bilateral chewing series with the balanced denture. The irregular responses cannot be interpreted as indicating positive or negative pressure. *B*, Recording of positive pressure from the same area during uniltaeral chewing on the left.

A. *If Balance Were Effective.*—Reduction of the balancing inclines of the nonworking (right) side would permit a slight tilting of the dentures, with loss of intimate contact with the tissues on that side. The recordings of the balancing side would show a decrease in both the magnitude of the pressure and the number of positive pressure strokes.

B. *If Balance Were Ineffective.*—Grinding of the balancing inclines would have little or no effect on stability of the denture, adaptation would remain unchanged, and pressures would be maintained.

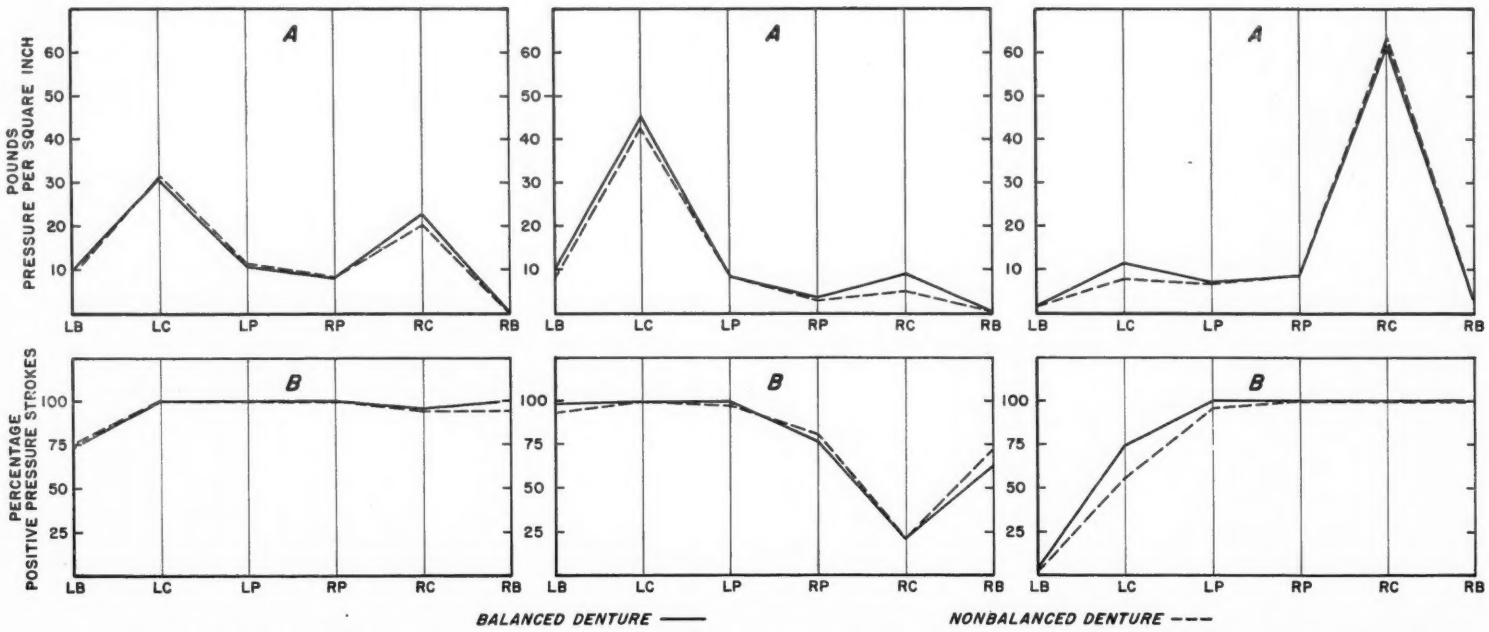
OBSERVATIONS FROM RECORDINGS

Chewing Bilaterally (Fig. 8, *A* and *B*).—

1. Positive pressure was present on the left ridge crest during 100 per cent of the chewing strokes, and on the right ridge crest during 94 to 96 per cent of the strokes, whether the dentures were balanced or not.
2. The nonbalanced denture exerted 3.1 per cent more pressure on the left ridge crest, and 11.0 per cent less at the right ridge crest than did the balanced denture.
3. Positive pressure was not recorded from the left buccal flange during about 25 per cent of the strokes whether the dentures were balanced or not.
4. Positive pressure strokes at the right buccal flange dropped from 100 per cent with the balanced dentition to 94.2 per cent with the nonbalanced dentition.
5. A slight decrease in pressure occurred at both buccal flanges when the dentition was nonbalanced.
6. Recordings from the palatal slopes showed very little difference between the balanced and nonbalanced dentures in regard to either the magnitude of the pressure or the number of positive strokes.

Chewing Unilaterally—Left Side (Fig. 9, *A* and *B*).—

1. Positive pressure was present at the left ridge crest during 100 per cent of the chewing strokes whether the denture was balanced or not. This factor was identical to that which occurred during bilateral chewing.
2. Pressure on the left ridge crest was approximately one-third greater than during bilateral chewing with both the balanced and nonbalanced dentures.
3. Positive pressure was recorded from the right ridge crest during only one-fifth of the chewing strokes whether the denture was balanced or not. This indicated a decrease of approximately 75 per cent as compared with bilateral chewing.
4. There was 39.8 per cent less pressure at the right ridge crest with the nonbalanced denture than with the balanced denture. In comparison with bilateral chewing, pressure on this crest decreased 61.6 per cent with the balanced denture and 74.0 per cent with the nonbalanced denture.
5. Positive pressure was present at the left buccal flange during 99.0 per cent of the strokes when the teeth were balanced, and during 93.6 per cent of the strokes when nonbalanced. This indicated increases of 33.1 per cent with the balanced denture and 24.2 per cent with the nonbalanced denture, as compared to bilateral chewing.



BILATERAL CHEWING

Fig. 8.

UNILATERAL CHEWING LEFT SIDE

Fig. 9.

UNILATERAL CHEWING RIGHT SIDE

Fig. 10.

Figs. 8, 9, and 10.—*LB*, Left buccal area; *LC*, left ridge crest area; *LP*, left palatal area; *RP*, right palatal area; *RC*, right ridge crest area; *RB*, right buccal area.

Fig. 8.—*A*, Distribution of pressure to six localized areas of the maxillary tissues during bilateral chewing. *B*, Positive pressure was recorded during almost 100 per cent of the chewing strokes in all areas except the left buccal.

Fig. 9.—*A*, As compared with bilateral chewing, pressure at the left ridge crest increased approximately 50 per cent during unilateral chewing on the left side. Pressure on the nonworking side dropped to less than 50 per cent. *B*, As compared with bilateral chewing, the percentage of positive pressure strokes increased in the left buccal area but decreased markedly in all areas of the right side.

Fig. 10.—*A*, During unilateral chewing on the right side, pressure at the right ridge crest increased by approximately 200 per cent, as compared with bilateral chewing. At the same time pressure on the nonworking side dropped to less than 50 per cent. *B*, As compared with bilateral chewing, slight increases in the percentage of positive pressure strokes occurred at the right buccal flange and ridge crest during unilateral chewing on the right side. At the same time the percentage decreased markedly at the buccal flange and ridge crest of the left side.

6. Pressure at the left buccal flange was 24.4 per cent lower with the nonbalanced denture than with the balanced denture. In comparison with bilateral chewing, this flange exerted 10.5 per cent greater pressure with the balanced denture and 2.2 per cent less pressure with the nonbalanced denture.

7. There was absence of positive pressure at the right buccal flange during 37.6 per cent of the chewing strokes when the teeth were balanced, and during 26.0 per cent when nonbalanced. This indicated decreases of 37.6 per cent and 21.5 per cent, respectively, as compared with bilateral chewing.

8. Pressures recorded from the right buccal flange were nearly identical with the balanced and nonbalanced dentures. In comparison with bilateral chewing, this flange exerted 60.5 per cent less pressure with the balanced denture and 32.6 per cent less pressure with the nonbalanced denture.

Chewing Unilaterally—Right Side (Fig. 10, *A* and *B*).—

1. Positive pressure was recorded from the left ridge crest during only 75.3 per cent of the chewing strokes when the denture was balanced, and during 56.4 per cent of the strokes when nonbalanced. This indicated marked decreases as compared with bilateral chewing when 100 per cent of the strokes showed positive pressure.

2. There was 32.7 per cent less pressure at the left ridge crest with the nonbalanced denture than with the balanced denture. In comparison with bilateral chewing, pressures in this area decreased 61.9 per cent with the balanced denture and 75.1 per cent with the nonbalanced denture.

3. Positive pressure was present at the right ridge crest during 100 per cent of the chewing strokes, whether the denture was balanced or not. This indicated an increase of 4.2 per cent with the balanced denture and 6.0 per cent with the nonbalanced denture, as compared with bilateral chewing.

4. There was 3.5 per cent more pressure at the right ridge crest with the nonbalanced denture than with the balanced denture. In comparison with bilateral chewing, pressures on this crest were approximately three times as great with both dentures.

5. There was almost complete lack of positive pressure at the left buccal flange. Pressures which were present were markedly lower than those recorded during bilateral chewing.

6. Positive pressure was present at the right buccal flange 100 per cent of the time, whether the dentures were balanced or not. In comparison with bilateral chewing, this indicated no difference with the balanced denture, but an increase of 4.8 per cent with the nonbalanced denture.

7. There was 13.7 per cent less pressure at the right buccal flange with the nonblanced denture than with the balanced denture. In comparison with bilateral chewing, pressures increased almost 3 times with the balanced denture and 4 times with the nonbalanced denture.

DISCUSSION

If the data obtained from the balanced and nonbalanced dentures, during bilateral chewing and unilateral chewing on the left side, are analyzed from the stand-

point of the premise previously set forth, it would appear that the merits of balanced occlusion were established. The deduction would be based mainly upon the decreased pressures imparted to the tissues at the right ridge crest after the dentures were modified by reduction of the balancing cusps of the right side. The decrease in pressure, even without a change in the number of positive pressure strokes, appears to indicate lowered functional contact with the ridge on the balancing side, with possible reduction in denture stability. This interpretation, pointing to the value of balanced occlusion, does not hold up, however, when data pertaining to unilateral chewing on the right side are studied. Here it is observed that reduced pressure was recorded from the balancing (left) side with the nonbalanced denture; a situation similar to that which occurred on the balancing (right) side with the nonbalanced denture during bilateral chewing and unilateral chewing on the left. No justification for this reduction in pressure on the balancing side during unilateral chewing on the right can be theorized, since the cusps of the left side were retained in balance throughout the tests.

Because nearly parallel pressure situations occurred at both sides of the modified denture, although only the balancing inclines of the right side were altered, it is felt that the advantages claimed for balanced occlusion were not substantiated for the particular dentures tested.

SUMMARY

Recordings were made of pressures imparted to subjacent tissues by balanced and nonbalanced dentures during chewing. Analysis of these records indicated that denture stability and force distribution were more favorable during bilateral chewing than during unilateral chewing on either side. It was found that pressures at the ridge crest of the working side increased 50 to 200 per cent during unilateral chewing. At the same time, the number of positive pressure strokes at the ridge crest of the balancing side decreased 25 to 80 per cent. Although it is doubted that many denture wearers regularly limit their chewing to one side alone, it would seem advisable for them to deliberately spread food across both food tables to obtain maximum stability and to prevent overloading of localized areas of the ridges.

In the studies conducted, the advantages of balanced occlusion did not appear to be established. The recordings indicated that bilateral chewing contributed much more to denture stability than did balanced occlusion. Obviously, many more studies must be conducted before the relative merits of balanced and nonbalanced occlusions can be evaluated with accuracy. Until this is accomplished, conclusions cannot be made.

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ADAPTATION AND THE HYBRID-PROSTHESIS

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DENTAL PROSTHESES like those shown in Figs. 1, 3, and 5 are constructed according to principles governing the shape and functions of ordinary complete dentures. Contrary to the usual type of complete dentures, these prostheses owe most of their retention to one remaining tooth or more. In this respect, they should be regarded as partial dentures. The retention is brought about by means of a simple device, acting very much like a dress snap. One part of it, the male part (Figs. 2 and 4), is attached to the retainer tooth and the other, the female part (Fig. 5), is attached to the denture base. It is called the B&C anchor. It is not possible to put dentures of this type into either of the two categories into which removable dentures usually are divided, viz., complete dentures and partial dentures, as the main characteristics of both types are included in this special type of denture. Although this type of denture has been described in dental literature since 1952 by Rehm,[1] Biaggi,[2] Dolder,[3] Lőfberg,[4] and Krogh-Poulsen,[5] none of these authors has tried to classify it as a specialty. But since it can be characterized as an intermediary form between a complete and partial denture, it might be called a hybrid-prosthesis.* The main reason for constructing a hybrid-prosthesis is that teeth otherwise condemned to extraction because of loosening and/or extensive caries might be utilized successfully as means of retention, and that is to the benefit of the person who must adjust himself to new dentures.

INDICATIONS FOR A HYBRID-PROSTHESIS

The hybrid-prosthesis is of great value where it is difficult, and frequently impossible, to obtain satisfactory retention by means of dentures of conventional design; e.g., for a person whose residual ridges are virtually nonexistent, and who is too old or too weak to undergo the surgical treatment which, under normal conditions, would have been the method of choice to remedy the deficiencies; or for a patient with phonetic difficulties, where a roofless denture is a matter of necessity. It is equally difficult to obtain satisfying results for patients with parts of the maxillae or the mandible resected, or for patients with xerostomia, macroglossia, or a cleft palate. The same applies to persons with neurologic disturbances, such as excessive salivation or gagging elicited by dentures, bruxism, or other nervous habits. However, partial dentures might be equally unsatisfactory, because the

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*A hybrid, according to Dorland,[6] is an animal or plant bred from two species.

remaining teeth are few and some of them may be extruded and disfiguring, or loose to such an extent that the prognosis for a partial denture is bad.

If a person has a set of dentures retained by B&C anchors, and he wants to remove them, he cannot just take them out. He will have to pull them out by means of his hands. Thus, the hybrid-prosthesis has advantages over the conventional complete dentures. If a patient is fitted with the usual complete dentures, it is a rather complicated job for him to adjust his mandibular movements to chewing, because he can only make use of the movements that will have a stabilizing effect on the dentures. He will have to concentrate on these movements, and develop them further, and he will have to suppress the movements that tend to dislodge the dentures. This trying procedure in more than one sense is simplified to a great extent by the hybrid-prostheses on account of the better retention, and they are an aid to the adaptational changes taking place in the various structures that make up the masticatory mechanism.

ADAPTATION

In the field of biology there is nothing more constant than change, and the human body is a biologic unit subject to this law. This tenet is true of the entire body, as well as of the organs of which it is composed, even down to the smallest biologic units—the cells—that constitute the various tissues in the organs. It is also true of the interaction between all of the major and minor units that are integrated by the circulatory and nervous systems.

Biologic structures would not be able to adapt their form and functions to new conditions without this innate faculty of changing.

Connective tissues have a high capacity for adaptation, and as the cementum, the periodontal membrane, and the alveolar bone can be regarded as highly specialized connective tissues, it is obvious that we shall find adaptive reactions against stresses in the periodontium. There are two kinds of reactions, degenerative and proliferative.[7]

If the stresses exerted on a tooth are within the limits of tolerance, the periodontium will accommodate itself to the challenge by a proliferative response. The stresses will incite the cells to action, and, in accordance with the loads hitting the teeth, new material is produced in the supporting structures and precipitated in adequate proportions. The cementoblasts will deposit new layers of cementum. The fibroblasts in the periodontal membranes will produce new and well-organized fibers replacing looser connective tissue. In the lamina dura, as well as in the adjacent cancellous bone, calcification is intensified. These changes must be the answer to the puzzling question which arises when, in a person with a reduced number of teeth, we find that the teeth are lodged firmly in their sockets. It should be pointed out that, in cases like that, we sometimes find that the increased function of the remaining teeth has caused a comparatively heavy abrasion of these teeth, which has produced a state of harmonious occlusion, concurrent with the preservation of the temporomandibular joints.

In other patients who have only a few teeth missing, we have found that the spaces created by extracting teeth are closed again after a period of time without any recognizable damage to the bone and/or the supporting tissues.

When a person has lost the molars in one or both sides of either jaw, he is said to have lost the supporting zones of the mandible. In a patient of this type we sometimes find symptoms of pathology in the temporomandibular joints. Often, however, they do not appear.

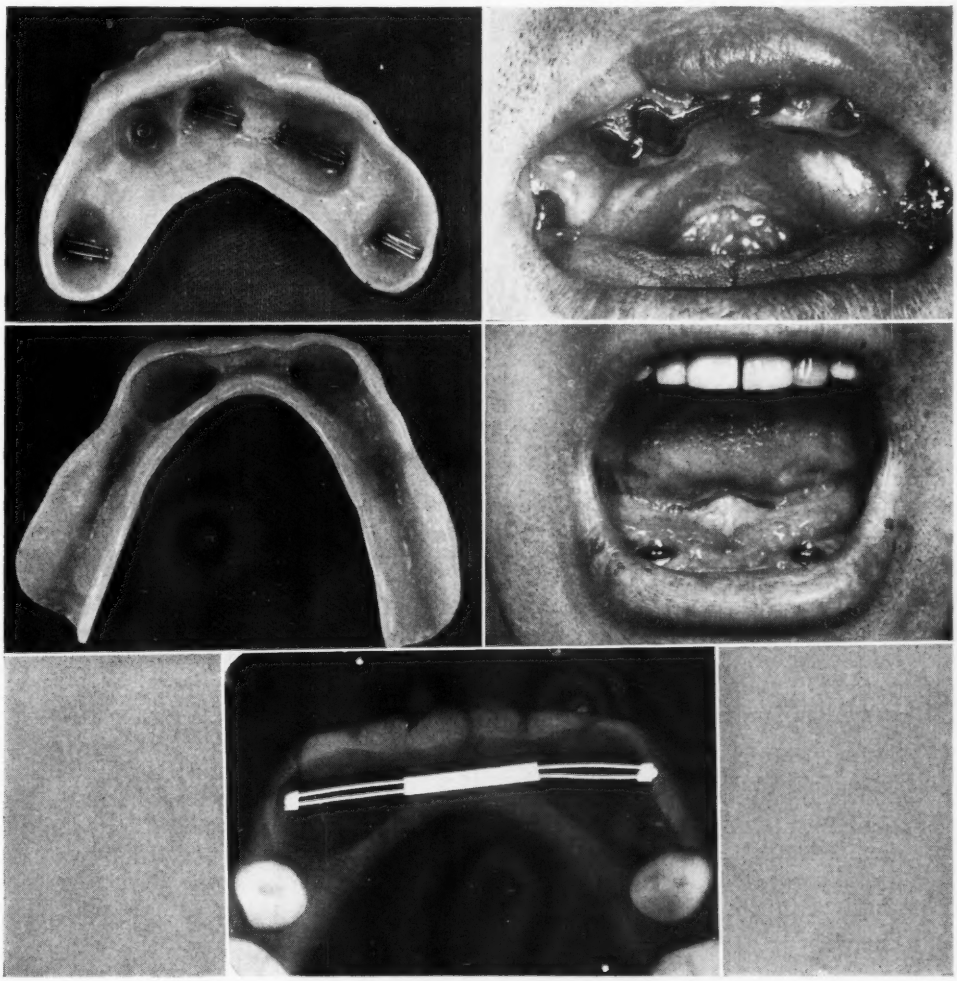

Fig. 1.—An upper hybrid-prosthesis showing the female parts.
Fig. 2.—The upper jaw with the male parts for which the hybrid-prosthesis shown in Fig. 1 was constructed.
Fig. 3.—A lower hybrid-prosthesis.
Fig. 4.—The lower jaw for which the hybrid-prosthesis in Fig. 3 was constructed.
Fig. 5.—A radiogram of the hybrid-prosthesis shown in Fig. 3.

It is likely that part of the explanation of this is to be found in adaptational changes which are supposed to take place in the joints, especially as the joints are built of essentially the same categories of tissue as those that go into the periodontal membranes. Therefore, at least some parts of the temporomandibular joints should be expected to react to stresses in very much the same way as do the

periodontal membranes. This contention seems to be supported by the works of Weinmann and Sicher,[10] Gerber,[11] Thielemann,[12] Häupl,[8] and Steinhardt.[9]

Another probable explanation is that parallel to the development of muscles seen in other parts of the body when powerful exertions are required of them, the external pterygoids may develop so they are able to give the condyles sufficient support and steerage in the articular fossae so that the impact will not exceed the limits of tolerance of the tissues in and around the joints. If that is the case, it is the external pterygoid muscles that have taken over the support which the condyles formerly received through the supporting zones of the mandible. Thus, the loss of some anatomic parts is counteracted by the physiologic activity in altogether different anatomic structures.

INSUFFICIENT ADAPTATION

Although adaptation acts within the limits of normal physiology, it is often seen that, because of the interdependence existing between structures and functions, a minor biologic unit has to be sacrificed in order to safeguard the function of a major biologic unit.

Krogh-Poulsen[5] stated his concept of this special point as follows:

> In cases, where the relation between induced force and biologic reaction is unfavourable, migration or loosening of the teeth may result. For example if the functional balance is lost after extraction of some molars on one side, the physiological response will show up as a tendency toward the creation of a new functional balance. In case molar contact is missing on one side the front teeth and the canine on the opposite side of the jaw will usually carry the whole occlusal pressure in lateral excursions to that side. If now the individual uses his musculature with great force, these teeth will become loose. If on the other hand the musculatory force of the individual is weak, the front teeth may migrate and spread without loosening.
>
> The result in both cases is the same: the teeth which disturb the function are in one way or another forced away so that a new occlusal balance is allowed to develop. Such adaptation of course is undesirable from the dentist's point of view, because it results in marked movements of too heavily loaded teeth and disturbs their esthetic value. However, in the scope of functional compensation by nature itself cosmetics and the fate of single teeth do not play any role.
>
> . . . . . .
>
> When functional disharmony exists and the influence of forces upon the tissues are not kept within physiologic limits, the occlusal forces develop into occlusal trauma and the periodontal reaction into a pathological breakdown.
>
> In such a situation artificial compensation leading to a new biologically acceptable functional balance is indicated.

This quotation represents a clear and well-defined directive telling the prosthodontist when to act, i.e., whenever the functions of the mouth, including the cosmetic function, are showing signs of a breakdown, they should be restored, otherwise not. A denture in itself is not the goal at which the prosthodontist should be aiming. He should regard a denture for what it is: a therapeutic measure by

means of which pathologic conditions can be relieved, and in some instances cured. If he is in doubt about the absolute demand for his intervention, he should let the masticatory mechanism have the benefit of doubt, in order to let it display its capacity for adaptation.

PROMOTION OF ADAPTATION IN THE MASTICATORY MECHANISM

With the object in mind—optimal function of the masticatory mechanism—the prosthodontist must realize that in complete dentures, balanced occlusion is a condition sine qua non. How can we otherwise expect to aid the masticatory mechanism with its alveolar ridges, temporomandibular joints, muscles and their nervous coordination in its efforts toward adaptation to restored function, since disharmony provokes disintegration of the various tissues and structures?

When a dentition has been mutilated by the extraction of teeth, and it has bad effects in the forms of elongation, interferences, and loosening of the remaining teeth, etc., the functional balance thus being totally lost, the prosthodontist will often find that the best way in which to retrieve the lost function is to remodel the entire occlusal pattern. In his wish to do so, the prosthodontist may feel inclined to make complete dentures, especially if the loss of teeth is rather extensive. This procedure has one big advantage to the dentist: it is fairly easy to establish balance in complete dentures compared to other measures, which might be indicated for the same patient. The reason is that, in planning and procuring balance by means of complete dentures, he is given a free hand to arrange all of the factors of occlusion except one: the inclination of the condyle path. The remaining factors he can adjust to the requirements of the patient.

PROMOTING ADAPTIVE REACTIONS IN THE CELLS

If the teeth are loaded too heavily or too little, a degeneration will take place in the supporting structures. The lamina dura will grow quite thin, and the periodontal fibers will be replaced by granulation tissue. After some time we will find that the teeth are loose in their sockets. The degree of loosening will be directly proportional to the amount of granulation tissue. So our goal should be to load the teeth neither too much nor too little in order to avoid degeneration, but just enough to provoke a proliferative reaction which will establish a positive adaptation in the supporting structures.

Furthermore, it is an acknowledged fact that in the forces hitting a tooth, the horizontal components can be the most destructive. In a full dentition, part of these components are transmitted to the periodontal membranes of the neighboring teeth, and in this manner the destructive character of these forces is more or less eliminated. However, in a dentition with only a few teeth left, it is the dentist who is to transform the forces hitting these teeth in such a way that the destructive components are minimized and optimal functional conditions are instituted.

Overloading can be avoided by cutting the crowns of the retainer teeth down to the gingivae, and by providing them with pin caps instead, like those used in

Richmond crowns. The caps are provided with a small knob (Fig. 6). Thus, the retainer teeth are provided with a much more favorable leverage relationship between the clinical roots and the clinical crowns when we deliberately reduce the length of the clinical crowns to approximately 1 mm. The destructive horizontal forces are now transmitted to the teeth by means of a considerably reduced lever. An even further advantage can be obtained by placing the point of attack of the forces exactly in the longitudinal axes of the retainer teeth. This is done by placing the knobs, which are the male parts of the B&C anchor, in the center of the pin caps. After having taken these measures, we can expect a more favorable response from the cells in the periodontal membranes.

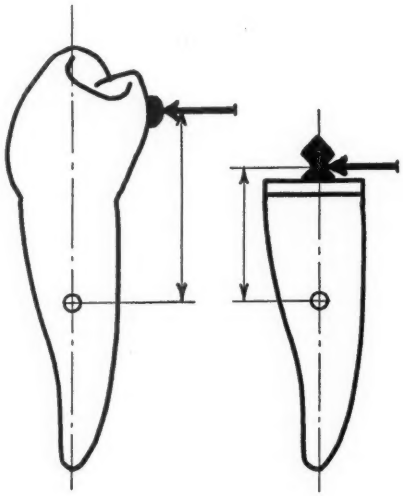

Fig. 6.—*Left:* Normal lever action between a clasp arm and a tooth. *Right:* In a reduced clinical crown (the root cap) there are more favorable conditions.

Underloading can be avoided by giving the occlusal surfaces of the pin caps a certain form, especially at the point where the cap turns into the knob. The surfaces in question must be formed like a roof. When the denture is in place, the springs, which are the female parts of the B&C anchor, will be below the knob, but above the cap (Fig. 7,*B*). If the denture is loaded on the side where the anchor has been placed, and especially in the immediate neighborhood of the anchor, the springs will slide down the inclined planes of the cap (Fig. 7,*D*). In this way, the springs are tightened, and the pressure is conveyed to the periodontal membranes of the retainer tooth. The idea is that by doing this we are able to stimulate the periodontal fibers enough to prevent their degeneration.

When seen in cross-section, the knob has the form of a square with rounded corners and is practically an ellipse in longitudinal section (Fig. 7,*A*).

When the denture is subjected to a pull, the movement is received and braked in practically the same way as previously when subjected to loading. Now, however, it is made possible by the springs tightening against the inclined planes of

the knob facing the cap (Fig. 7,*C*). If there are anchors on both the right and the left sides, lower right and left cuspids for instance, and the patient uses the right side of his denture for chewing, the springs on the right cuspid will be subjected to pressure, while those on the left cuspid will be subjected to a pull. That provides a corresponding position of the springs in relation to their retainer teeth as shown in Fig. 7, *D* and *C*.

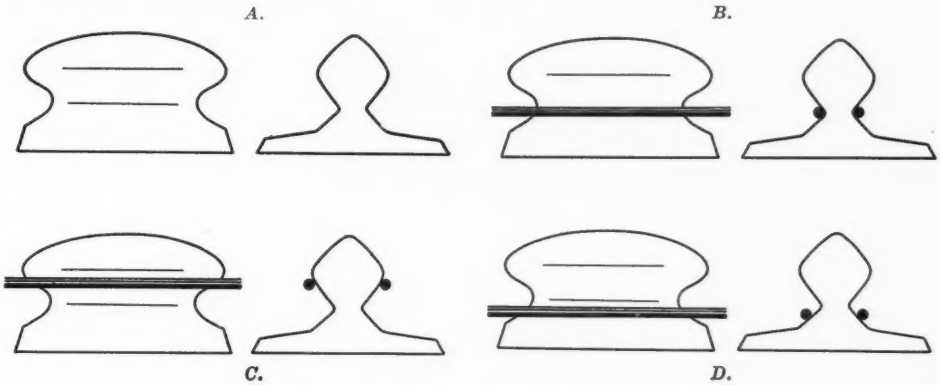

Fig. 7.—*A*, A root cap fitted with a knob. *B*, The springs in neutral position. *C*, The springs tightening against the inclined planes of the knob. *D*, The springs tightening against the inclined planes of the root cap.

PROMOTION OF PSYCHOLOGIC ADAPTATION

Most people are concerned about their future as denture wearers. Some of them may even know someone who has dentures which fit badly, hurt, and look like "false teeth." Now and then a well-kept secret is revealed when an upper denture comes loose. That is a most embarrassing scene to witness, and occasionally it has an exasperating effect upon the unhappy denture wearer. Everyone dreads that situation. Nobody wants to lose face, especially not persons who feel that with their last teeth gone, they themselves go out of circulation. They worry for months and years about their present and future status, and work themselves into a neurotic state of mind which can be most trying even for their families. The prosthodontist can ease the mental burdens for these patients by telling them that whatever they fear will not come true with a hybrid-prosthesis.

Other cases of minor psychiatry can be handled by the prosthodontist with equally good results. An example of this is that of a young man who was 26 years of age when dental treatment was started. He was a very industrious and intelligent person. He had studied for several years and passed his examinations with fine recommendations. In spite of that, he got only minor jobs because of his reserved manners and shy behavior. In fact, he had an inferiority complex and was unable to rise to any situation demanding any determination on his part. He knew all too well that his personality lacked charm, and he was afraid that people would not like him because of his appearance. His features show a highly disproportioned face. The lower part, especially, is disharmoniously built with a protruding mandible and receding maxillae (Fig. 8). That was the sole cause of his inferiority complex. It was a pleasure to follow the change that he under-

went during the treatment and afterwards. Three months after the dentures were inserted, we find an altogether different person, smiling in a natural way (Fig. 9). The most conspicuous thing about the whole matter was that he now showed the very self-reliance which he formerly lacked. By means of a hybrid-prosthesis it was possible to remold his features. This was accomplished by making the upper denture very prominent, and setting the front teeth well off and very much in front of the ridges in order to push the upper lip forward. In this way, the disharmonies in his face were softened. The procedure meant that the upper denture was exposed to a rather heavy pressure from the muscles of the upper lip, a pressure which a denture of conventional design would not have been able to withstand.

Fig. 8.

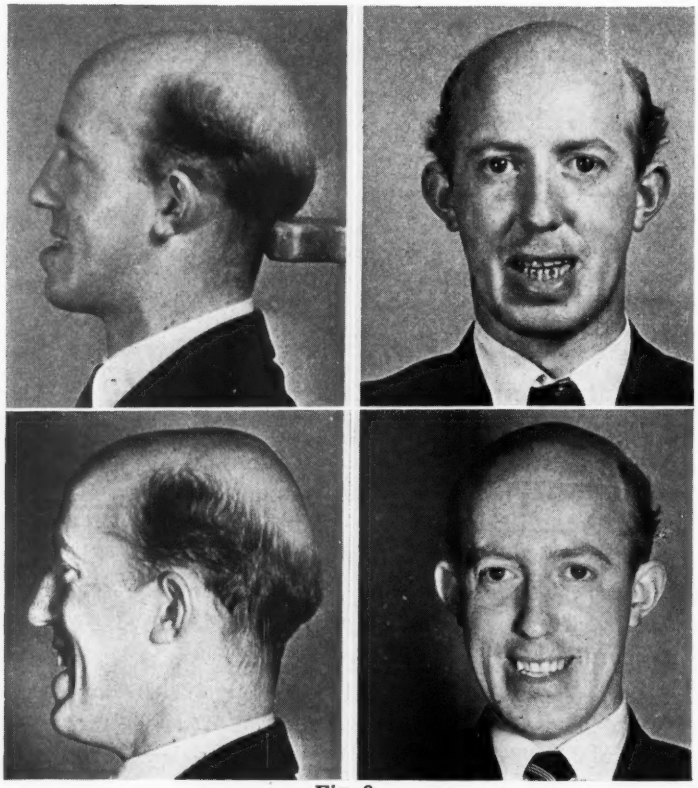

Fig. 9.

Fig. 8.—The patient when the treatment was started.
Fig. 9.—The patient with hybrid-prostheses.

PROBLEMS CONCERNING THE RETAINER TEETH AND THE B&C ANCHOR

The B&C anchor can be applied and be useful in giving added retention even for patients where only a single tooth remains as a retainer tooth. If more teeth are available, the natural teeth intended for the construction of the hybrid-prosthesis should be selected according to certain rules. The principle which aims at attaining a maximum of indirect retention in partial dentures should be followed. This maximum is achieved when the clasp line passes through the denture base in such

a way that the denture base is divided into two equal parts (Fig. 10). A downward pull on the denture base on one side of the clasp line (fulcrum line) is counterbalanced by a corresponding upward pressure on the supporting tissues of the denture on the opposite side of the clasp line. The counterpressure prevents the denture as a whole from being tipped away from the supporting tissues, and is the acting principle in the concept of indirect retention.[13]

Fig. 10.—Diagram of clasp (fulcrum) lines dividing the denture bases into two equal parts.

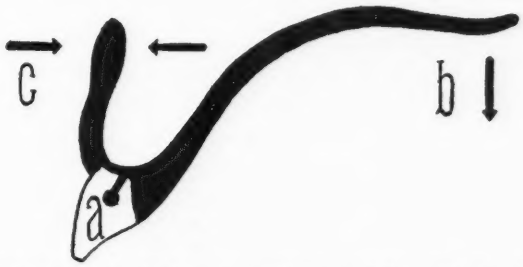

Fig. 11.—A pull at *b* causes the denture to rotate around the anchor *a*. This movement is transformed into a pressure and counterpressure at *c*.

Fig. 12.—The hatched parts are the parts of the denture base providing indirect retention.

Fig. 13.—Diagrams of denture bases with multiple clasp lines.

If the alveolar ridges are high, unilaterally placed teeth can be utilized, because the denture base is extended to comprise the labial and buccal flanges and provide the indirect retention. Fig. 11 shows how a downward pull at the distal end of the denture (at *b*) involves a rotation around the anchor (*a*). However, this

movement is braked by a counterpressure that is just as powerful and which arises at the flange (at *c*). That means that the clasp line passes through the denture base under more favorable conditions in respect to indirect retention (Fig. 12). If the alveolar ridges are low, indirect retention can be created in a different way. That can be done by utilizing several teeth as retainer teeth. In those patients, the indirect retention is usually taken over by the direct retention of one or more anchors (Fig. 13).

However, nothing prevents the direct, as well as the indirect, retention of a hybrid-prosthesis from being better than that of a corresponding complete denture, even in patients where the retainer teeth are placed unilaterally in flat alveolar ridges. In patients, for instance, where the upper right second molar and the upper right first bicuspid are acting as retainer teeth, the indirect retention of an upper denture could be brought about by the lingual springs tightening against the corresponding slopes of the knobs, i.e., the slopes facing lingually as well as toward the pin cap, whereas the buccal springs will tighten against the inclined planes of the pin caps facing buccally. If the long axes of the knobs are parallel to the alveolar ridge, there is a situation like the one in Fig. 14,*B*. If the axes are at right angles to the ridge, we will find a situation similar to the one shown in Fig. 14,*A*.

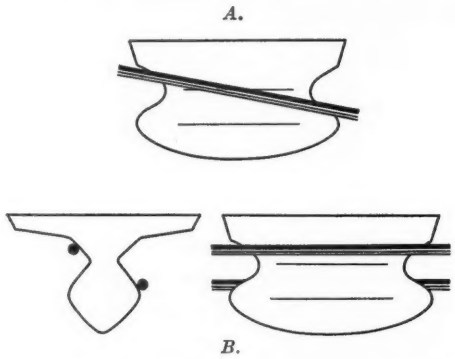

Fig. 14.—Additional possibilities of movement of the B&C anchor.

It depends upon circumstances, whether the long axes of the knobs should be parallel or at right angles to the alveolar ridges. Because of the flow of the acrylic resins, it must be expected that if the springs are fastened in the denture base material, they will probably loosen in the course of time. To prevent that, tiny twin tubes are polymerized into the flanges of the denture next to the retainer teeth to keep the springs in place in the denture. As long tubes are retained better in the denture base material than shorter ones, the tubes should be made as long as possible. The easiest way to accomplish this is to place the springs and the long axes of the knobs parallel to the alveolar ridges (Fig. 15, *left,* and Fig. 16). But if for some reason, such as a bulky tuberosity, access to the male parts of the anchor cannot be obtained in this manner, the solution shown in Fig. 15, *right* can be used. It should be pointed out that, for obvious reasons, whenever possible the retainer teeth should be splinted together, either directly by casting the pin caps of neighboring teeth in one piece (Fig. 17, *lower middle*) or indirectly in other

cases by connecting the teeth by means of a bar (Fig. 17, *lower right*). The bar and the pin caps too are cast in one piece in order to make the construction as strong as possible.

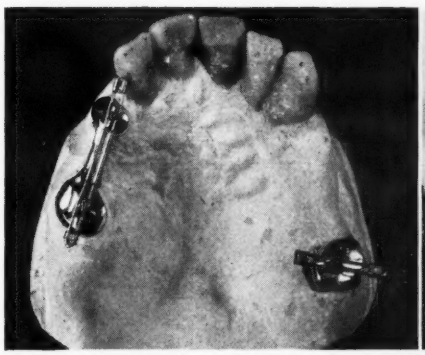

Fig. 15.

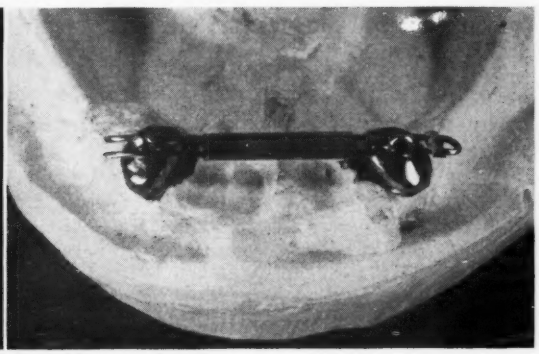

Fig. 16.

Fig. 15.—The male parts and the female parts of the B&C anchor in place on a cast.
Fig. 16.—The hairpin-shaped wire placed on the male parts, and fitted with two of its three twin tubes.

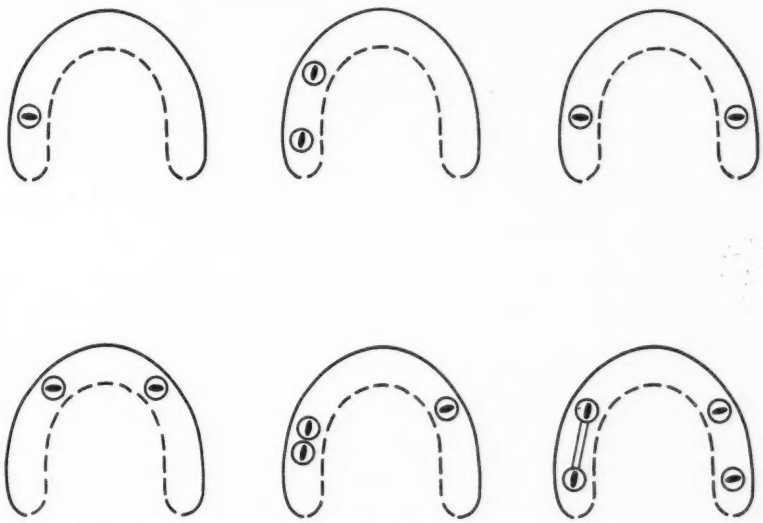

Fig. 17.—Different ways of utilizing remaining teeth as retainer teeth.

PROBLEMS CONCERNING THE SELECTION OF MATERIALS

It is a great advantage to the dentist if the materials that go into the construction of the B&C anchor can be found among those regularly used by the general practitioner for other purposes. If so, he is familiar with their properties and is able to make the anchors in his own laboratory.

A palladium alloy, Paliag M., was found suitable for casting the male part of the anchor. The hardness of this alloy (Wickers 152-155) makes it quite suitable for the purpose. The female part of the anchor, i. e., the springs, is made of

Svedia spring-hard clasp wire, 0.6 mm. The twin tubes that are to keep the springs in place in the dentures have an inner lumen of 0.7 mm. They are made by soldering together True-Chrome-Alloy tubes of the dimension mentioned above, and of a type well known by all orthodontists. By choosing tubes with an inner lumen which is bigger than the diameter of the springs, the springs in function are able to slide a little back and forth inside the tubes. In that way the spring-like effect of the female part is likely to be increased. Thus, the possibilities for the springs to break under the load of mastication are minimized; but even if they should be broken, it is only a matter of 15 minutes to repair the damage.

TECHNICAL PROCEDURE

Naturally, the procedure described here can be varied according to the wishes and experience of the dentist.

At the Chair: After root canal treatment, the retainer teeth are ground down to the level of the gingivae. The preparations are carried out in the same manner as for root caps, and impressions of the teeth and root canals are made.

In the Laboratory: Dies and their corresponding transfers are made.

At the Chair: After being lubricated with oil, each transfer is placed upon its retainer tooth, and an alginate impression is made. The transfers will remain in the impression, if they have been provided with a knob having an adequate undercut which is intended for the retention in the impression material.

In the Laboratory: The dies are put in place in the transfers, and the impressions are cast in stone. Occlusion rims are made.

At the Chair: The necessary jaw relation registrations are made with the aid of the occlusion rims.

In the Laboratory: The jaw relation registrations are used for orienting and mounting the casts on the articulator. The orientation is necessary in order to get a comprehensive view of the interrelations of the casts, and to determine the location of the knobs of the B&C anchors. The pin caps and knobs are modeled in wax. Each cap with its knob is cast in one piece and replaced on its corresponding die. Sometimes it is necessary to place the knobs slightly lingual to the center of the pin cap, after seeing how much space there is, and taking into account the due esthetic considerations. However, it will always be of utmost importance to place them as close to the center as possible. The teeth are set up in the usual way in balanced occlusion.

At the Chair: The setup is checked regarding its functional balance and its physiognomic function. Any necessary corrections are made in the mounting, articulator adjustment, and esthetic arrangement of the teeth.

In the Laboratory: The female part of the B&C anchor is now constructed and placed in the denture. A Svedia spring-hard clasp wire 0.6 mm. is bent to the shape of a hairpin so it can grasp the knob on the anchor. If the longitudinal line of the knob faces buccolingually, the hairpin-shaped wire must be fitted to reach the lingual surface of the lingual flange of the denture from the buccal surface of

its buccal flange. Then, two pieces of the twin tubes that are soldered together are fitted to a length of approximately 3 mm., and a piece is placed at both ends of the hairpin-shaped wire. The latter is then put in position on the knob of the anchor. If the hairpin-shaped wire is placed parallel to the alveolar ridges, and there are two anchors that can be grasped by one hairpin-shaped wire, three pieces of the twin tubes are used (Figs. 3 and 15).

To prevent the marginal gingivae of the retainer teeth from becoming traumatized while the denture is in function, it is necessary to provide sufficient relief on the side of the denture facing the gingivae. That is done by giving the anchors and their immediate surroundings a 4 mm. plaster cover. However, the twin tubes must not be covered (Fig. 18). They should be closed with a tiny bit of plaster only at the ends facing the external surfaces of the dentures. This measure is absolutely necessary, otherwise there would be the risk of the acrylic resin penetrating into the tubes while it is curing (Fig. 18).

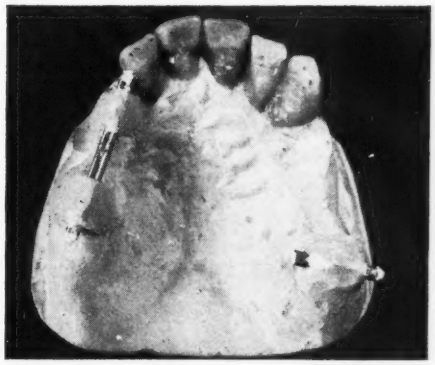

Fig. 18.—Plaster covering the pin caps and the ends of the tubes where these meet the external surfaces of the denture.

The question of the necessity of this kind of relief was investigated by professor Krogh-Poulsen. The reliefs provided in the finished dentures were filled with hard wax in two cases. After a short period of time, we could see that the marginal gingivae were pressed against the root caps like a thin collar. Moreover, there were clear signs of inflammation. A few days after removing the wax, conditions were back to normal.

If the reliefs take up so much space that there is insufficient space for porcelain teeth, the porcelain teeth must be replaced by acrylic resin teeth.

After having finished modeling the wax denture, it is packed, pressed, and cured, as is usual for any other denture.

After the resin has cured, the flask is opened and the cast with the denture on it is removed. The plaster cast and the dies are removed from the denture. The male part of the anchor will be found to be still fastened to the female part of the anchor. The female part and the male part are separated and the hairpin-shaped wire is removed from the twin tubes.

The cast is replaced in the denture, and both are returned to the articulator. If any increase in the vertical dimension has occurred during the processing, it is eliminated.

If the part of the denture closest to the twin tubes appears to be too thick, the parts in question, as well as the tubes, can be reduced to about 2 mm. The tubes are ground under cold running water, as the heat produced by grinding would otherwise destroy the part of the acrylic resin in the immediate neighborhood of the tubes. The denture is then polished and finished as usual. The hairpin-shaped wire, which was previously removed, is now pushed into place as far into the tubes as possible. Both its free ends, which in some cases are liable to protrude from the lingual surface of the denture, are cut short so they are flush with the acrylic resin. The free ends of the hairpin-shaped wire must be able to move a little inside the tubes, when the springs are loaded, while the patient is chewing or making occlusal contact. Care must be taken to make sure that the acrylic resin is not pressed into the tubes when the openings where the tubes meet the lingual and buccal surfaces of the denture are covered with cold-curing resin. When this resin has hardened, it is polished.

At the Chair: The male parts (the root caps with the undercut knobs) are cemented to the retainer teeth, and the denture is put in place. The denture borders and the occlusion are checked and corrected, if necessary. The patient is instructed about the hygiene and checkups before he is dismissed.

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SOME ANATOMIC FACTS AND FANCIES RELATIVE TO THE MASTICATORY APPARATUS

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FOR THE PAST TWENTY-FIVE years, I have had the interesting experience of teaching dental students, including freshmen and juniors. During the last eight years I have also had the pleasure of conducting a course in the anatomy of the head and neck for postgraduates in dentistry. Throughout these years I have never lost sight of the fact that the subject of human anatomy is a science within its own right, and is not a handmaiden to the health professions any more than are the sciences of chemistry, physics, or physiology. And yet, meanwhile, I have felt it my obligation to conscientiously endeavor to acquaint myself with the applications of anatomy to dentistry, and to point out those applications in my teaching as the occasion arose.

As an anatomist, standing on the side lines of the field of dentistry and observing the professional training, ethical conduct, technical procedures, methods of diagnosis and treatment, scientific concepts, quality and scope of the literature, and status of nomenclature of the dental profession, I have gained certain impressions, most of which I am happy to confess are quite favorable. Based on the assumption that for the most part professional groups, as well as individuals, welcome helpful suggestions and constructive criticisms (or at least should tolerate them) when offered by nonbiased and friendly critics, it is my objective in this article to call to your attention some rather common errors, or perhaps I should say careless mistakes, in biologic and anatomic terminology and concepts as they appear in the dental literature.

As a layman, I would not presume to hazard any opinion concerning the technical aspects of dentistry, and I hope I will not leave the impression that, as an anatomist, I set myself up as a one-man censor board or as an authority relative to what are the correct or accepted terminology and basic principles of anatomy as related to dentistry. On the contrary, I approach my objective with considerable humility and with a feeling of trepidation, fully aware of the fact that I will greatly disappoint those of you who anticipate any helpful and practical suggestions from me that will enable you to render better prosthetic dental service to your patients. Moreover, I am cognizant of the likelihood that some of you

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may take offense at my constructive criticisms and be inclined to take them personally. However, I assure you that my intentions are solely to encourage scientific accuracy and unanimity of anatomic nomenclature.

My method of approach has been to go directly to your "bible," so to speak, THE JOURNAL OF PROSTHETIC DENTISTRY, and to examine its contents critically to find examples of discrepancies in anatomic terminology and principles. In the event that I am accused of being a semantic purist, I call your attention to the following statements quoted from the JOURNAL in support of my point of view. According to an editorial, "Words should be used with a uniform meaning. Symbols that mean one thing to one person and another thing to another person are useless."[1] That some of the authors share this viewpoint is evident from this opening statement in one of the articles: "Progress in the sciences depends largely on the use of appropriate terms. This is true in dentistry."[2]

DISCREPANCIES IN ANATOMIC TERMINOLOGY

First, I should like to direct your attention to the frequent misuse and abuse of the term "anatomy," which is often used erroneously as synonymous with structure. The word "anatomy" is derived from a Greek word meaning "to cut up," but, according to modern usage and as defined by medical dictionaries and textbooks of anatomy, it means the science or study of the structure of the animal or human body. In short, it is not synonymous with structure but rather is the study of the structure. In the light of this interpretation, the expression "anatomy of the edentulous ridge" when used to refer to the structure of the ridge actually means the study of the structure of the ridge. In reality, the expression "anatomic structure," which is greatly overworked, is redundant, the adjective anatomic being unnecessary.

The word physiology is likewise commonly misused. For example, the statement appears that "lateral stresses are among the most damaging components of chewing physiology."[3] Without meaning to be facetious, the novice might interpret the expression "chewing physiology" to mean masticating a textbook of physiology. According to the physiologists and to the dictionary definition, physiology is the science or study of functions of a living organism and its parts. Hence the words physiology and function are not synonymous, and the expression "physiologic function" is also redundant, the adjective physiologic being unnecessary.

Less seriously, perhaps, but nevertheless often falsely used, is the word "tissue." As defined in histology, which is the science or study of tissues, a tissue is an aggregation or organization of similar cells and their intercellular products specialized in the performance of a particular function. Histologists recognize only four main kinds of tissues, namely, epithelium, muscular, nervous and connective, and they ordinarily use the word tissue only with reference to these. Tissues are the structural components of organs in the same sense as bricks and mortar are the structural materials of a smokestack or chimney. In referring to the latter, one does not ordinarily call it "bricks and mortar" but a "smokestack" or "chimney."

Therefore, in the strict sense of the word, tissue is not synonymous with organ or with a structure or membrane such as, for example, the mucous membrane or mucosa which lines the oral cavity or covers the alveolar process or ridge. In short, mucous membrane is not the name of a tissue; rather it is composed of several kinds of tissues, namely, epithelium, muscular, and connective. Actually, the only tissue that is visible in the oral cavity or that a denture base contacts is the epithelium of the oral mucosa, and although the underlying muscles and bones will produce imprints on impression material and hence on denture bases, such impressions are produced by the gross or morphologic character of the oral structures, the tissue components of which are microscopic elements. Therefore, according to the histologic interpretation, the statement, "An impression is a registration of mouth tissues made with an impression material,"[4] should be modified to read, "An impression is a registration of oral structures made with an impression material." It is suggested for the sake of scientific accuracy that the term "oral mucous membrane" or "mucosa" be substituted for that of "oral tissues" whenever feasible in the literature of prosthetic dentistry.

MISUSE OF TERM "ALVEOLAR BONE"

Another term that is frequently erroneously used in the JOURNAL—at least, it is erroneous according to the histologic concept—is "alveolar bone" when reference is made to the bone that makes up the alveolar process. The alveolar process is generally described as consisting of compact or cortical osseous material externally, and of spongy or cancellous bony substance internally. The tooth sockets or alveoli, when present, are lined with a layer of cortical bone to which Sharpey's fibers of the periodontal membrane are attached. According to most textbooks on oral histology, it is this layer of bone that is designated "alveolar bone" and is synonymous with the term "lamina dura."[5] Needless to say, when viewed in this light, with the loss of teeth and the subsequent disappearance of the alveoli and the resorption of its lining bone, no alveolar bone as such remains in an edentulous ridge. In fact, the question is raised as to the logic of referring to the edentulous ridge as the alveolar ridge since the alveoli have disappeared. Several investigators have described the histologic changes that take place within an alveolus following the extraction of a tooth in experimental animals. They unanimously agree that after the reorganization of the blood clot, new cancellous bone develops and fills in the original alveolus with a cortical layer developing on the crest of the ridge, the process of ossification being followed or even accompanied by resorption of the newly formed cancellous bone including the alveolar bone or lamina dura.

In view of these findings, the employment of the expression "edentulous alveolus" is questionable. Thus, "since the edentulous alveolus must always bear some part of the masticatory load, alveolar resorption is likely to occur."[6] Inasmuch as an edentulous alveolus is said to be filled in within a period of about two months,[7] after which time it ceases to exist, it would be about as logical to continue to call it an alveolus as it would be to call a hole in the ground a hole after it had been refilled with dirt. It is possible of course that the expression "edentulous alveolus" quoted above was meant to be used synonymously with edentulous alveolar process or ridge, which of course is an unfortunate synonym.

I was surprised at the great frequency with which the singular form "maxilla" is used to indicate the upper jaw. For example, "The maxilla was normal in appearance with good firm ridges."[8] It should be remembered, of course, that the upper jaw is formed by a pair of maxillae which unite in the median plane at the intermaxillary and median palatal sutures. It is, therefore, incorrect to say that a maxilla has ridges, since each has only one ridge. It need not be pointed out that in case of malignancy involving only one maxilla, its surgical removal will leave the patient with half an upper jaw, that is, with still another maxilla.

The name "inferior maxillary bone" has become obsolete in favor of the term "mandible" for the bone of the lower jaw. In spite of the fact that the inferior maxilla has been relegated to the bone yard, the terms "intermaxillary" and "bimaxillary" are still commonly used in place of the more modern and acceptable word "maxillomandibular" when referring to the space between the upper and lower edentulous ridges. In this connection also, it should be mentioned that the old familiar term "submaxillary" as applied to the salivary gland and duct is being replaced by the more logical adjective "submandibular" in more recent editions of some of the anatomy textbooks.

STIMULUS VERSUS IMPULSE

It was not too surprising to find in one article the terms "afferent" and "efferent" stimuli,[9] since this is a fairly common error, not only in dental but also in medical literature. The functional unit of the nervous system is a reaction system, which consists of five components, namely, (1) a receptor or sense organ, (2) an afferent neuron, (3) an adjustor mechanism, which is in the central nervous system, (4) an efferent neuron, and (5) an effector or organ of response such as a muscle or a gland. The function of the receptor or sense organ is the reception of stimuli, which means external changes in the environment of the receptor. Such changes result in internal changes that occur in the receptor and are transmitted by way of the afferent neuron to the adjustor mechanism in the brain or spinal cord, and thence outward over an efferent neuron to the effector, which responds by contracting if it is muscular or by secreting if it is glandular. These internal changes that are aroused in receptors and are transmitted inward to the central nervous system are known as afferent impulses, the exact nature of which is not understood, but they are known to be accompanied by electrical waves and are thought to be chemical in nature. The same impulses are conducted outward from the central nervous system by means of an efferent neuron to the effector, but they are then called efferent impulses because of the outward direction they take. It is evident from this brief description of the fundamental pattern of the nervous system that, first, impulses, not stimuli, are classified as afferent and efferent; second, stimuli are changes outside the reaction system and do not enter it; third, impulses are the changes that occur in receptors resulting from outside stimuli, and are conducted from the receptors at first toward the center, and thence outward to the effectors; fourth, the nervous system obviously would be functionless without the aid of the system of sense organs, and, last, muscles and glands would likewise be functionless without the aid of the nervous system upon which

they rely to supply them with efferent impulses—not stimuli. Neurologists have classified receptors into (1) exteroceptors, which receive external stimuli and are on the surface or periphery of the body, (2) interoceptors, which receive internal stimuli and are in visceral organs, and (3) proprioceptors, which are located in muscles, tendons, and ligaments, and are stimulated when these structures are stretched. As is well known, it is the latter class of receptors that plays such an important role in the maintenance of the vertical dimension of the rest position. In an interesting paper dealing with kinesiology as related to vertical dimension, the author,[10] in referring to the proprioceptors, calls them propriopathic preceptors. Certainly the term preceptor must be a typographical error, since it means "one who teaches." If that is the connotation desired by the author, it lacks support by all of the standard textbooks on neurology, which should be authoritative.

Time will not permit further discussion of anatomic terminology. Before leaving the subject of nomenclature, however, I should like to comment briefly on three terms that appear in the JOURNAL frequently, and which fall in the category of prosthodontic terminology. I find it very difficult to become reconciled to the employment of the expression "denture teeth" which is used to indicate teeth of the artificial denture. Granted that by usage the term denture in dental prosthetics has come to mean a set of artificial teeth, nevertheless, according to the dictionary definition it also means a set of natural teeth. It would seem that, for the sake of uniformity, the use of the adjectives artificial and natural would clarify any doubts about its meaning. Next, as an anatomist, I question the validity of the term "throat form" with reference to the palatal and alveololingual areas of the mouth. According to textbooks on anatomy, the throat is the same as the pharynx, and it may even refer to the anterior part of the neck. In either case, it seems rather farfetched to use the terms upper or lower "throat forms" when both regions are far removed from the throat and are actually in the oral cavity.

Inasmuch as there is a vertical dimension of rest position as well as a vertical dimension of occlusion, the failure in many of the articles to specify which of the two types of vertical dimension is meant is sometimes confusing. At least it is to the lay reader, and as evidence that members of the profession may also sometimes be confused, I quote the following suggestion that appears in a paper published in the JOURNAL: "At times the term is used without qualification as to which dimension reference is being made. When we speak of vertical dimension we should make our meaning clear and indicate to which of these dimensions we are actually referring."[11]

SOME ANATOMIC MISCONCEPTIONS

Under this category appear several examples of misstatements of anatomic facts, and in some instances there occur highly exaggerated statements. In reading some of these distorted notions, one wonders whether it is a question of carelessness, lack of information, or assumption of the right of subjective judgment. In any case, it is unfortunate that some of the statements appear in print, primarily for the reason, as was pointed out in an article in the JOURNAL, that "mistakes can find their way into print and remain unnoticed for scores of years, serving, like false signposts, only to mislead and to confuse."[12]

Moreover, as the editor expressed it in announcing his policy in the first number of the JOURNAL, "Freedom of speech imposes a responsibility on those who talk or write."[13] There is one school of thought that holds to the belief that only those who have the facts are entitled to an opinion, and those lacking the facts are entitled only to a belief. I cannot say that I subscribe wholeheartedly to that concept, but, I am convinced that an author assumes a grave responsibility for his expressed beliefs or opinions, call them what you may, because the average reader is inclined to accept, more or less blindly, without question or skepticism, printed statements as authoritative opinions and factual information. That is especially true with the young reader who lacks practical experience and looks to textbooks and the professional journals for his sources of information.

BIOLOGIC CONCEPTS

I should like to comment about some general biologic concepts that appear from time to time, not in the JOURNAL exclusively, but also in dental literature generally and, at times, in textbooks. These concepts are an attempt to account for normal human structure and are evidently based on the human tendency to inject the element of purpose into nature. Thus we read about nature's plan of occlusal design,[14] "The maxilla is designed by nature to absorb and dissipate pressure,"[15] and, that, "Teeth were not designed by nature to have ideal surfaces for clasps."[16] Of course, in questions of this sort anyone is allowed his own beliefs, and argumentation is certainly not the solution. However, from a biologic point of view, the assignment of purpose or of intelligent planning to nature is unscientific, since human beings are not endowed with the mental or psychic capacity to fathom the phenomena of nature to that extent. This does not mean that the human mind should not strive to seek intelligent explanations to account for structure. I suspect that ever since the beginning of mankind the mind of man has been occupied with questions concerning his origin, his reason for being on earth, how his body came to be constructed the way it is, how his organs function, and his fate after death. To explain the answers to these questions by simply saying that they are all part of nature's plan is no answer at all. The great contribution of the Greek philosophers to civilization is that they were the first to be unwilling to blindly accept such an explanation, and instead sought for rational interpretations or natural laws thereby founding scientific discipline. In biology, the term "teleology" applies to the concept that structures arose because of a purpose or a need. Thus, according to the teleologic view, man possesses eyes in order to see or because there was need for organs of sight, whereas according to the biologic view, as far as we know, man sees because he happens to have inherited eyes from lower animal forms which had gradually evolved by the differentiation of cells specialized in the reception of light waves. The same biologic principles apply to man's possession of his teeth and jaws.[17]

INTERRELATION OF STRUCTURE AND FUNCTION

Another explanation frequently offered to explain the nature of bodily structure is that function determines form or structure. As one author expresses it,

"This fact is generally conceded by artists, architects, engineers, scientists generally."[18] Doubtless the statement is true. However, anatomists generally are inclined to the opposite view, namely, that the structure of an organ determines its function—in other words that structure came first, and that as a result of the particular structural arrangement, microscopic as well as macroscopic or morphologic, it was enabled thereby to perform its particular function. This is not to deny the influence of function on structure, for, as is well known, the skeletal system relies for its normal development on the proper functioning of the muscular system. Thus, it is a truism that disuse atrophy of the muscles of the arm will result in atrophy of the bones of the arm, or that bony processes, to which muscles and tendons are attached, are more prominent in well-developed muscular individuals than in those with poor muscular development. The same principles apply naturally to the lower jaw of modern man as opposed to that of primitive man whose food was coarser, requiring him to apply greater force in chewing with the masticatory muscles, resulting in more massive development of the mandible. On the other hand, there is a possibility that this bone, as well as the rest of the face, is undergoing evolutionary changes, not necessarily because of the nature of the modern diet, but because of genetic factors. These factors are not to be ignored in considering the structure versus function problem, because it must be remembered that they determine the pattern of bone architecture. In other words, given normal masticatory muscle development, the mandible normally develops into a typical-shaped bone, the features of which are readily recognizable, and never develops into a bone that resembles a humerus or a maxilla.

There are two ideas concerning some muscles that appear time and time again in dental literature, and with which I am in disagreement. One of these concerns the mylohyoid muscle, which is so often referred to as "the floor of the mouth." I presume it is so named because it assists in elevating the floor of the mouth during swallowing. The fact that "two things that are equal to the same thing are equal to each other" is not proof that the mylohyoid muscle is, therefore, the floor of the mouth since it elevates it. It would seem logical that the floor of the mouth should be visible within the mouth cavity, in the same manner that the floor of a room is visible within the room; and since that which is seen in the floor of the mouth cavity is the mucous membrane extending from the mandibular gingiva lingually to the tongue, that is, the alveololingual sulcus, the latter should be considered the floor of the mouth. Moreover, between the mucous membrane and the mylohyoid muscle there is a considerable space, the sub- or paralingual space, which is occupied by several important structures, including the sublingual gland, deep part of the submaxillary gland, submaxillary duct, the lingual and hypoglossal nerves, the lingual vein, and the sublingual branch of the lingual artery. No one considers these structures, which lie superior to the mylohyoid muscle, as being in the mouth cavity, so if the mylohyoid muscle is to be called the floor of anything, it is that of the sublingual space.

The other idea with which I disagree is that of referring to the facial muscles of expression, particularly the buccinator muscle, as "accessory muscles of mastication" simply because they serve to move the bolus of food about in the oral cavity during the process of mastication. These muscles do not perform this func-

tion any more than do the muscles of the tongue, and yet I have never seen the latter muscles classed as "accessory muscles of mastication." The muscles of mastication, as opposed to the muscles of expression, insert into and serve to move the mandible during the chewing process; so do the suprahyoid muscles. And yet the latter muscles are rarely if ever given the label "accessory muscles of mastication" which they more richly deserve than do the muscles of expression.

In one article, touch receptors are classified under the heading of special sense organs, and, it is claimed that "some investigators classify the senses of heat, cold, and pain as special senses separate from that of touch."[19] These ideas are certainly contrary to those held in the standard textbooks on neurology and physiology, according to which the only receptors that are classified as special sense organs are those of smell, taste, sight and hearing, and in none of them are the senses of touch, heat, cold, or pain classified as special senses. Invariably they are classified as general senses, primarily because the receptors are not highly specialized and because they are distributed generally throughout the surface of the body, as opposed to the special sense organs which are highly specialized and are concentrated in the head region. Also, in naming the nerves concerned with taste, the lingual branch of the fifth nerve is included, along with the chorda tympani branch of the facial nerve. Actually, the only taste fibers contained in the lingual nerve are those of the chorda tympani, which are hooking a ride, so to speak, on the lingual nerve.

NEED FOR CLARITY OF EXPRESSION

One author makes the statement, "When masticatory load is applied to the denture base, some of the fluid content of the tissues will be forced back into the general circulation, as is evidenced by the blanching of the tissues under a clear acrylic tray."[20] Blanching of the tissues may occur when masticatory load is applied to the denture base; however, it is certainly not due to the "tissue fluid" being forced back into the general circulation, but rather, because the pressure occludes the blood vessels in the area, thus shutting off the blood supply momentarily. Employment of the idea of "tissue fluid" in this situation is unfortunate. According to textbooks on histology and physiology, "tissue" fluid is that fluid which bathes the tissue cells and is derived from the plasma of the blood by the process of osmosis through the capillary membranes. It is said to be relatively stationary but is constantly being filtered off by diffusing through the walls of the lymphatic capillaries, where it becomes lymph, and is eventually returned to the blood-vascular system, where it again becomes plasma. This continuous process of dialysis is explained on the basis of osmotic pressure, and it is not affected by external pressure applied to the tissues unless damage occurs to the capillary walls. The foregoing criticism may be grossly unjust, as I might possibly have misinterpreted the author's statement, in which event I apologize. Nevertheless, it does serve to emphasize the need for clarity of expression.

Another illustration of the need for authors to weigh their statements carefully before putting them into print is the following sentence: "In the human skeleton, nature provides us with no instance where a mass of cancellated bone

is used for any other purpose than that of resisting compressive forces."[4] I am well aware of the fallacy of removing a sentence from its context to criticize its meaning. Nevertheless, this statement is not correct, either in or out of its context, because cancellated bone does serve another highly important function, namely, that of hematopoiesis, or the formation of blood cells due to the presence of the contained red marrow.

Frequently statements are made without due regard for basic anatomic principles. For example, the claim is made that "the mandible has the characteristics of a long bone, but with more cancellous tissue."[15] Let us see what are the characteristics of a long bone. According to all the standard textbooks on human anatomy, a long bone is characterized by having a cylindrical shaft and two ends. The shaft is composed mostly of compact bone and contains a spacious medullary cavity filled with yellow marrow; the ends are broader and thicker than the shaft and consist of cancellous bone covered with a thin layer of compact bone. It is obvious that the mandible possesses none of these characteristics. It is also stated in the same article that "the maxillary bone is highly cancellous, and has a thin protective cortex covered by a fibrous layer of mucosa of varying, but usually satisfactory thickness and density."[15] If by this statement is meant only the alveolar process and oral surface of the palatal process of the maxilla, it is unchallenged. But, if we take the statement at its face value, it certainly is open to criticism because the bulk of the maxilla, i.e., its body, is hollowed out, forming the antrum, which is bounded by relatively thin walls of cortical bone, covered on the outside by periosteum.[21] The author states that the "thin, nonresilient covering of fibrous tissue" of the mandible "resembles the periosteal covering of a long bone except that it is thicker." In regard to this statement, it should be pointed out that this fibrous tissue covering should resemble the periosteal covering of a long bone because that is exactly what it is, namely, periosteum, or mucoperiosteum if the author is referring only to the covering of the alveolar process.

With regard to the architectural features of the mandible, it is interesting to note that the claim is made in one of the articles that whereas the alveolar process is composed of relatively soft cancellous bone, the mandible proper is composed of hard compact bone.[22] Are we supposed to interpret this statement to mean that cortical bone is lacking in the alveolar process, and, conversely that cancellous bone is absent from the body and rami of the mandible? Obviously, an affirmative answer to this question is unthinkable.

ANATOMIC RELATIONS OF EDENTULOUS RIDGE

I was surprised to read that "the origin and insertion of muscles of mastication and muscles of expression do not emerge on or near the ridges."[23] I confess that I cannot comprehend this statement, because it is generally well known that normally fibers of the buccinator muscle are attached to the buccal shelf and buccinator crest of the mandible and to the alveolar process of the maxilla in the molar region. Moreover, when the edentulous ridge is resorbed, several muscles may attach on the ridge, notably the buccinator, mylohyoid, genioglossus, and mentalis.[24]

I was also surprised to read that the extension outline form of denture bases is constant and consistent because it is always governed by the same structures which are in the same position in every patient. It was pointed out, for example, that the masseter muscle will always be found to extend anterior to the soft retromolar pad on the mandible.[25] The question arises as to the interpretation of the phrase concerning structures always being in the same position. Obviously, the masseter muscle always extends anterior to the retromolar pad, the buccinator is always buccal to the ridge, and the mylohyoid is always lingual to the ridge. However, the relative position of these muscles to the retromolar pad or to the edentulous ridge changes according to the amount of resorption of bone. I do not think there is any question but that the distance between the anterior border of the masseter muscle and the ramus of the mandible is greatly increased in patients who have long been edentulous due to the ramus having shared in the resorption process. Naturally, the anterior border of the masseter stays put, but its relative position with respect to the anterior border of the ramus changes.

This same author[25] suggests that if sufficient space does not exist between the retromolar pad and the maxillary tuberosity to permit the presence of the thickness of artificial dentures in that area, it must be provided by surgical reduction of the tuberosity. The latter, he claims, will be found to be cartilaginous tissue. I have never examined this tissue microscopically. However, I should be greatly amazed to find any cartilage at that site, since the maxilla is a membrane bone and cartilage is foreign to it. According to textbooks on oral pathology, this mass of tissue consists of dense fibrous connective tissue.[26]

The claim is also made in the same article that the greater palatine foramen "will be found approximately 1 cm. toward the median line from the position originally occupied by the second molar tooth."[25] According to standard textbooks on human anatomy, and as was verified on several skulls, this foramen is invariably found medial to the third molar tooth.

In my experience as an anatomist, I confess I have not had much occasion to observe the natural plane of occlusion in the living mouth, and, therefore, my qualifications to express an opinion about occlusion may logically be questioned. In spite of the possibility of being accused of trespassing on ground "where angels fear to tread," I question the validity of the following statement: "The natural plane of occlusion is parallel to the floor when the patient is standing or sitting in a normally relaxed position."[27] My basis for doubting the truth of this statement is the strong likelihood that the mandible would also be in the rest position, in which position the plane of occlusion of the mandibular teeth would not be parallel either with that of the maxillary teeth or with the floor. Moreover, it is very likely that the rest position of the head and of the mandible varies with the individual, and is based on comfort and habit. In any event, I am not willing to accept the statement without proof of its validity.

MICROSCOPIC ANATOMY

I confess my lack of experience in microscopic anatomy. However, I have endeavored to keep in touch with the current literature and recent developments in that field in spite of the fact that I have not taught the subject for several years.

Although I make no pretense of speaking with authoritative opinion, I should like to comment briefly about a point of view expressed in an article[28] relative to the role of the periodontal membrane when axial force is applied to a tooth. Several writers adhere to the viewpoint expressed in that article, which states that when axial force is applied to a tooth the enveloping alveolar bone and periodontal membrane are subjected essentially to compression, "not tension, as the fiber school maintains." According to the compression school, the fluids contained in the blood and lymph vessels of the periodontal membrane function as an hydraulic shock absorber in counteracting the pressure resulting from an axial force applied to the tooth. As is expressed in the same article, "the laws of hydrostatics tell us that any substance, no matter how fluid when enclosed in a rigid container, takes on the same rigidity as the container. Thus, the periodontal membrane, provided it is completely contained, would under these circumstances become as rigid as bone . . . the pressure upon peridontal membrane and alveolar bone must be essentially compressive."[28] According to exponents of the fiber theory, the interstitial spaces with their blood vessels and lymph spaces do appear compressed.[5] However, this school maintains that the connective tissue fibers of the periodontal membrane support the tooth in its socket in a manner very similar to that found in a suspension bridge or in a hammock, and when the tooth is subjected to a force parallel to its long axis, such as a direct occlusal force, all of the oblique supporting fibers are tensed, as a result of which the load is distributed equally among these fibers.[29] Moreover, according to this school of thought, compressive forces when applied directly to the periodontal membrane, result in traumatism and may produce pathologic changes and loss of function.

THE TEMPOROMANDIBULAR JOINT

Finally, in concluding the discussion of anatomic misconceptions relative to the masticatory apparatus, I shall comment briefly on some statements about the structure of the temporomandibular joint. I assume that my readers are aware of the structures that enter into its formation, and the fact that it is really a combination of two joints, one between the condyle and the articular disc, and another between the disc and the glenoid fossa. I cannot subscribe to the view held by one author, that "the joint between the condyle and the meniscus, within any functioning range of the teeth, is a pure ball-and-socket joint comparable to any other ball-and-socket joint in the body."[30] There are many arguments that could be produced to refute such a classification of this joint, not the least of which is the fact that, without exception, all standard textbooks of human anatomy employ essentially the same criteria or bases for classifying a joint as a ball-and-socket joint, and according to none of these authorities does the joint under consideration possess those criteria. For one thing, a ball-and-socket joint, such as the shoulder joint, is so constructed as to permit movement around an almost infinite number of axes passing through the center of the ball. Neither do I agree with the author who makes the statement that "the temporomandibular joint has the freest range of movement of any of the body joints."[31] Certainly no one will dispute the fact that this joint has a wide range of free

movement, but, on the bases of directions of movement and degrees of displacement, it cannot compare with the shoulder joint. My authority for this claim is one of the leading textbooks on human anatomy, according to which "there is more freedom at the shoulder joint than at any other joint in the body."[32]

It is well known that the temporomandibular joint is completely surrounded by an articular capsule. Contrary to one of the articles, it is not "encapsulated by tendonous connective tissue,"[33] but by ligamentous connective tissue, and, neither is the entire joint encapsulated by the strong temporomandibular ligament,[34] which is to be found only on the lateral aspect of the capsule.

With regard to the nature of the tissue which covers the articular surfaces, and of which the articular disc of this joint is composed, opinions vary. Thus, according to one article, the condyle and glenoid fossa are covered by articular cartilage.[35] According to the majority opinion, as expressed in several articles, the disc is composed of fibrocartilage, and the articular surfaces are covered also with fibrocartilage. The latter type of tissue, as described in modern textbooks on histology, consists of thick, compact bundles of collagenous fibers which are parallel with one another and are separated by narrow clefts in which are located encapsulated cartilage cells.[36] Microscopic examination of the articular disc, and the tissue which covers the articular surfaces of the condyle and glenoid fossa reveals that the disc is composed of dense fibrous connective tissue, and that the condyle and fossa are likewise covered with dense fibrous connective tissue overlying a layer of hyaline cartilage. Sicher[37] points out that islands of cartilage may appear in the fibrous layer, and, more rarely, in the disc in aged individuals

SOME PHYSIOLOGIC MISCONCEPTIONS

Since I am not a physiologist, it may be presumptuous of me to offer any criticism about statements concerning physiologic concepts which appear in the JOURNAL. But, since I have been playing the role of a critic in this article, I cannot refrain from commenting on some of the statements. For example, the claim is made in several articles that the opening and closing of the mouth is involuntary. I think you will agree that at a given signal you could open and then close your mouth voluntarily. The reason you could perform these movements voluntarily is that they are produced by skeletal, striated, voluntary muscles that are directly under the control of the voluntary motor area of the cerebral cortex. I suspect that the reason some people think of these movements as being involuntary is that they are usually performed reflexively, and there is a tendency to think of reflex movements as being synonymous with involuntary movements. As a matter of fact, most of our bodily movements, such as breathing, talking, walking, gesturing with our arms and hands, and even driving a car are reflex movements. But they are brought about by contractions of voluntary muscles, and at any given instant one can voluntarily produce these movements, such as contracting the diaphragm or the intercostal muscles in order to take a deep breath. On the other hand, there are many reflex movements, such as peristaltic movements of the gastrointestinal tract and contraction of the heart and blood vessels, which are involuntary because they are produced by visceral, involun-

tary muscle fibers that are not under the control of the cerebral cortex. It is only with reference to these latter movements that the expression involuntary movements should be applied.

ROLE OF MUSCLES DURING MANDIBULAR REST POSITION

Another mistaken notion that is expressed in many articles is that in the so-called rest position of the mandible, the muscles involved are completely relaxed and at rest. Time does not permit a lengthy discussion of the fundamental physiologic principles of muscle tissue or of muscles as organs. I hazard the opinion that such a discussion by a qualified physiologist would be very profitable. It will suffice to say here that the proprioceptors within the muscles and tendons involved in elevating and depressing the mandible play an important role in maintaining a state of partial contraction or tonus of these muscles, so that when they are not actively contracting to produce movements of the mandible their tonus serves to hold the mandible suspended in the position commonly referred to as the mandibular rest position. If the muscles were completely relaxed as some claim, the force of gravity would cause the mandible to be so displaced downward that the mouth would be wide open, which, of course, is not the case when the mandible is in the so-called rest position. Moreover, the term "rest" is a misnomer, since not all of the muscle fibers in these muscles are at rest, but some of them are in tonic contraction, during which state they function according to the all-or-none law of muscle physiology.

Several other comments could be made concerning various ideas expressed about mandibular rest position, but I shall only call your attention to the following divergent views: (1) "When all the teeth are lost the mandible swings in space,"[38] and (2) "The rest position of the mandible is determined by the musculature and not by the teeth."[11]

No article dealing with a review of the masticatory apparatus would be complete without some reference to the role played by the mandibular muscles in masticatory as well as nonmasticatory movements of the mandible. The problem cannot be dismissed by simply saying, as does one author, "The sciences of physics and physiology are responsible for mandibular movements."[39] Obviously we cannot lay the blame on these sciences for the complicated movements which the mandible is capable of making. There is one thing we can do about these movements, however, and that is to cease kicking the problem around with the use of subjective reasoning and the obsolete and unreliable methods of armchair science. Rather, the scientifically trained physicists and physiologists should solve it. As an anatomist, I confess that all I know about the action of the mandibular muscles and the movements which occur in the temporomandibular joint is what I have read in anatomy textbooks and in dental literature. I am not satisfied with most of the information I have thus obtained, and I question the reliability of the sources because of the methods commonly used in acquiring the data. It is very encouraging to know that the problem of mandibular movements and the role played by the various muscles in producing them is now being attacked with the aid of scientific apparatus and methods.[40] Since I do not possess any informa-

tion concerning the action of the mandibular muscles other than what already appears in the literature, I have nothing to add to the already controversial issue.

In concluding this critical analysis, I think the editor of the JOURNAL, the associate and contributing editors, and the organizations which sponsor it are to be congratulated for having conceived and launched it successfully, and for the worthy contributions which it makes to the field of prosthetic dentistry. If I have succeeded in germinating the idea of the need for authors to critically examine their statements for possible errors in anatomic and physiologic nomenclature and concepts, before submitting their articles to the JOURNAL for publication, I shall feel my efforts will not have been in vain.

Finally, I should like to suggest that one of the most worthy contributions which the sponsoring organizations of the JOURNAL could make would be to subsidize original research projects by qualified, scientifically trained physiologists and physicists, with the objective of solving some of the biologic problems bearing upon prosthetic dentistry. The time has arrived for concerted, cooperative efforts for their solution, rather than by individual, hit-and-miss efforts.

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DISCUSSION

Some Anatomic Facts and Fancies Relative to the Masticatory Apparatus, by Linden F. Edwards, Ph.D.

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DR. EDWARDS HAS USED a subtle teaching method in his excellent article. He has brought many of us into his story by analyzing what we have said or written. It is like a show called "Line-Up" on television. On this show, two detectives round up various characters who may be guilty of some misdeeds, and place them in the police line-up for observation and identification by their victims. So, as he progressed, we were kept alert to find out if we were in his line-up.

Dr. Edwards has worked *alone* in producing his "line-up," but nevertheless he has brought together a surprising number of misstatements in prosthodontic literature, and placed them before us who are the victims as well as the culprits. No doubt each of us has recognized the errors of which he is guilty. Dr. Edwards has the necessary background in anatomy, and in knowledge of the problems of prosthodontics to find logical suspects for his "line-up," and to serve as a "censor board" of the references to anatomy in the literature.

It may be profitable for us to review the accusations in order to recognize our "crimes" and perhaps to say a word or two in our defense.

ANATOMIC TERMINOLOGY

It is obvious that we have misused the terms anatomy and physiology in the strict sense of their meaning. Some of this misuse may have come about through ignorance of the names of the exact structures involved, but I feel that part of the trouble arises through a possible lack of proper terms for expressing our ideas. For example, to speak of the "structures of the edentulous ridge" does not seem to present the same connotation as the "anatomic structures of the edentulous ridge." We need a term to indicate the structures involved collectively, so they may be indicated en masse without naming them, for use in discussions of impressions. Perhaps Dr. Edwards can suggest a proper term for this purpose.

Another complication occurs because we place structures (the complete or partial dentures) on structures which are a part of the oral anatomy.

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We are careless about our use of the term "tissue," but in the strictest interpretation, "mouth tissues" are registered in an impression since the oral structures are made up of tissues. However, carrying this analysis to the ultimate in relation to the subject, we are more concerned with these tissues when they are organized into structures than with the tissues per se.

The discussion of the use of the term "alveolar bone" when it is the residual ridge is quite timely. It involves a basic understanding of the bony foundation on which we build dentures. This foundation must be understood if proper use is to be made of it. It should be pointed out that there is a need for an easy way to distinguish between the residual ridges, and the parts of the maxillae and mandible which were never a part of the alveolar ridge.

The criticism of such terms as "maxilla," "inferior maxilla," "intermaxillary," and "bimaxillary" is certainly justified. Their use is probably due to a habit of speaking in the vernacular as much as to any other cause. We are in the habit of thinking of the two maxillae as a single unit (the upper jaw), but to say "the upper jaw" would not sound scientific enough to some.

The discussion of the nervous system is a direct and simple step-by-step outline of the way in which nerve impulses are stimulated and transmitted in order that structures can be placed in function. This is worthy of study by those who wish to understand the neuromuscular system.

Our use of the term "denture teeth" has been criticized, and I think rightly so. However, I would suggest that, in spite of the dictionary definitions, the term "denture" be used to indicate a set of artificial teeth, and the term "dentition" be reserved to indicate natural teeth in position in the mouth. This distinction could eliminate the need for modifying words, such as "natural" or "artificial" in connection with teeth in the mouth. In referring to teeth out of the mouth, the words natural or artificial would still be needed.

It is well that Dr. Edwards has called to our attention the misuse of the term "throat form." This is another of those terms which have a special connotation to the men who use them, but which are not anatomically correct. It is a term which is easy to use, but it should not be too difficult to learn to say palate or alveololingual sulcus in the interest of accuracy.

I am particularly happy that note was made of the variations of intent when the term "vertical dimension" is used. It should not be too difficult to be specific.

ANATOMIC MISCONCEPTIONS

As Dr. Edwards points out, many authors are guilty of teleological reasoning. In some instances, this is due to an effort to bolster an argument, while in others it is used as an expedient method of illustrating structural relations. Regardless of the reason for its use, it is obvious that teleological reasoning is not correct according to the *biologic* concept of anatomy.

The statements which designate the mylohyoid muscle as "the floor of the mouth" are examples of poetic license in a scientific field, or I might say "loose talk," for I do not believe that anyone really considers the mylohyoid muscle to

be the floor of the mouth. What we need is more accuracy in prosthodontic literature.

I should like to defend the designation of the buccinator muscle as an accessory muscle of mastication. Certainly, it does not move the mandible any more than the tongue moves the mandible. However, the buccinator muscle and the tongue do play a part in the mastication of food. They help to control the position of food in the mouth so that the teeth can carry out their function in the process of mastication. While I may be guilty of loose talk in this analysis, it seems to me to be a practical analysis of the things that occur during mastication.

The statement "some of the fluid content of the tissues will be forced back into the circulation" was criticized. This is another example of loose talk. Obviously, Dr. Edwards is correct on the basis of his analysis of the structure of tissues. However, it is quite likely that the author of the statement was presenting evidence against a statement to the effect that "tissue is incompressible." Both of these statements are only half truths as they were used. One statement considers the fact of blood and lymph as a part of the makeup of tissues (he meant structures), and the other ignored all consideration of the blood and lymph supply to tissues.

The discussion of the structure of the mandible and its covering is particularly important because it relates so closely to the use which is made of it by prosthodontists. The objectives and techniques of impression making are directly affected by the facts of the anatomy of the mandible and its covering tissues. As was pointed out, some of the statements in the literature describing the structures on which dentures are built simply are not factually true.

I cannot argue with the statements Dr. Edwards has made regarding the misconceptions relating to the temporomandibular joint, the physiology of mastication, and mandibular movements. I can only urge that we be more careful first in what we say, and second, in how we say it.

The suggestion of research projects directed toward gaining fundamental information of an unbiased nature seems to merit further consideration by all of the organizations interested in prosthodontics. This "line-up" has pointed out the need for such an effort. The charges are recorded; we should ask ourselves, "Where do we fit in?"

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ONE-PIECE CASTINGS FOR FIXED BRIDGEWORK

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DENTISTRY HAS RECOGNIZED that, where indicated, fixed bridgework is the finest type of prosthetic service that we can offer the patient. However, it has also been recognized that there have been certain unsatisfactory procedures in the fabrication of these restorations. Soldering has introduced certain inaccuracies and imperfections that have been vexing and discouraging. This article will present a method to help eliminate this problem.

Since the introduction of the disappearing pattern method of casting,[1] it has been recognized that an accurate method of reproducing and replacing lost tooth structure and missing teeth was available. Similarly, with the introduction of hydrocolloids for impression making,[2] we can fabricate our castings accurately by the indirect method.[3] Now, by carrying this technique forward to its next logical step, we can completely eliminate soldering from the construction of fixed bridgework.

The disadvantages of soldered connections are many. Solder shrinks upon cooling, thereby distorting the relationship of the units of the restorations. To overcome this, it has been necessary to solder each connection separately so as to avoid compounding this problem. This necessitated repeated investing and heating, which are manipulations that introduced inaccuracies. Solder is softer than casting gold, and acts to contaminate the cast units, causing the bridge to become weak and discolored. Despite the skill of the operator, it is very difficult to control completely the flow and positioning of the solder, and it is necessary to trim the metal after soldering in order to have the contact points placed correctly and the occlusion correct. This latter point is especially true in unit-built porcelain bridges. Lastly, the entire soldering procedure is very time consuming and unnecessary.

It is possible to eliminate all soldering. The entire bridge can be cast in one solid unit, with every detail of the anatomy completely within our control, and so accurate that there is no pull or pressure on the abutments when the restoration is seated.

THE HYDROCOLLOID IMPRESSION

The impression is made in hydrocolloid as described by Sears,[2] Buchmann,[4] Shapiro,[5] Rubin,[6] Kendrick,[7] and others. The hydrocolloid is boiled for ten minutes and then transferred to a holding bath which maintains the temperature of the material at 140° F., where it is always ready for use. After the preparations are completed, the teeth are carefully cleaned and dried. Pieces of kite string, impregnated with a zinc chloride solution, are carefully placed below the free margin of the gingivae around the abutment teeth. While this is being accomplished, the impression tray is filled with the impression material and placed

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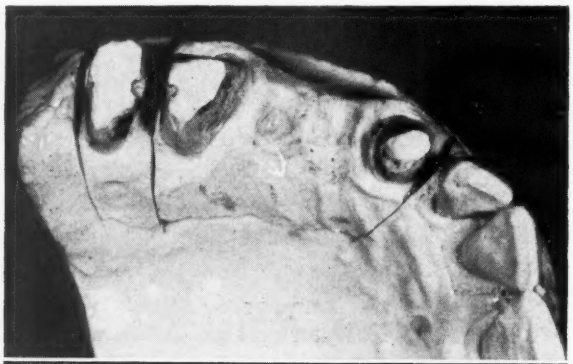
in a tempering bath at 115° F. The kite strings are removed from the gingival sulci. The margins of the preparations should be freely visible and accessible. The teeth are dried again, and the impression is made. Hydrocolloid is run from a syringe into the gingival sulci and around the teeth, covering the preparations, and carefully eliminating all air bubbles. The tray is removed from the tempering bath; the outer, soft layer of hydrocolloid is removed, and the tray seated in the mouth. After chilling the impression material with water at 65° to 70° F. for about three to five minutes, the impression is removed with a quick decisive movement along

Fig. 1.



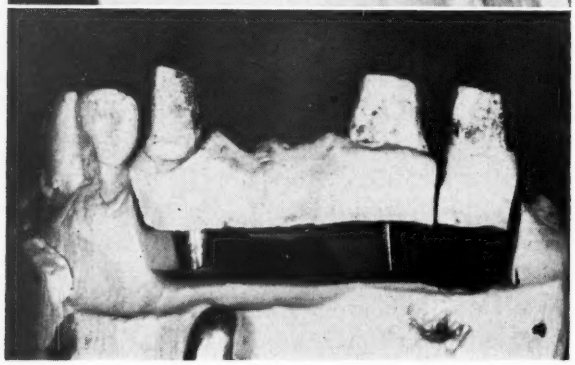


Fig. 2.

Fig. 1.—The stone master cast poured in an original hydrocolloid impression.
Fig. 2.—The master cast with the removable dies elevated from their seats.

the long axes of the preparations. The tray should not be rocked or teased out, as this will distort the impression. The maxillomandibular relationship and the counter cast are made at this time in the usual manner. The impression is cleaned, and the cast is poured.

THE TEMPORARY RESTORATION

It is important that a temporary bridge be placed which will maintain the abutments in position. This can be accomplished efficiently and esthetically. Before the preparations are started, an alginate impression is made and placed in water until after the preparations are completed. After they are completed, the alginate impression is reseated in the mouth, and checked for easy insertion and removal.

Where the teeth are missing, alginate is cut out of the ridge portion of the impression to connect with the impressions of the abutment teeth. A thin mix of self-curing plastic of the proper shade is placed in the alginate impression, and the impression is seated over the preparations in the mouth. After the plastic is set, it is removed from the mouth for finishing. This temporary plastic splint

Fig. 3.

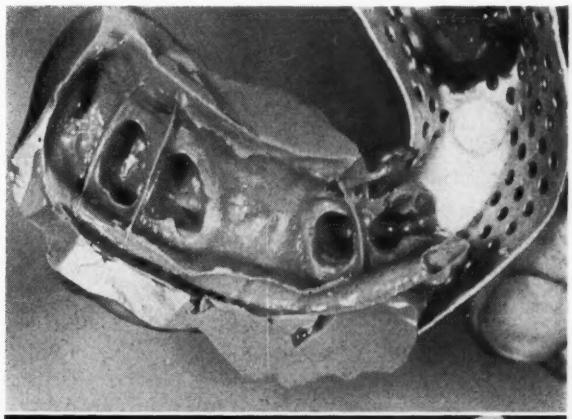


Fig. 4.

Fig. 3.—The hydrocolloid impression of the master cast for fabricating duplicate refractory cast in Cristobalite investment.

Fig. 4.—The refractory cast and the original master cast.

will serve to hold the teeth in position and allow the patient to function normally when it is cemented in the mouth with temporary cement.

The master cast is poured with removable die sections (Figs. 1 and 2), and articulated with the counter cast. The dies are trimmed and prepared for waxing.

FABRICATION OF THE RESTORATION

Two distinct methods are possible for fabricating the one-piece fixed bridge.

The small (three unit) bridges are completed on the master cast. The crowns for the abutments are waxed individually as are the pontics. They are then joined

Fig. 5.

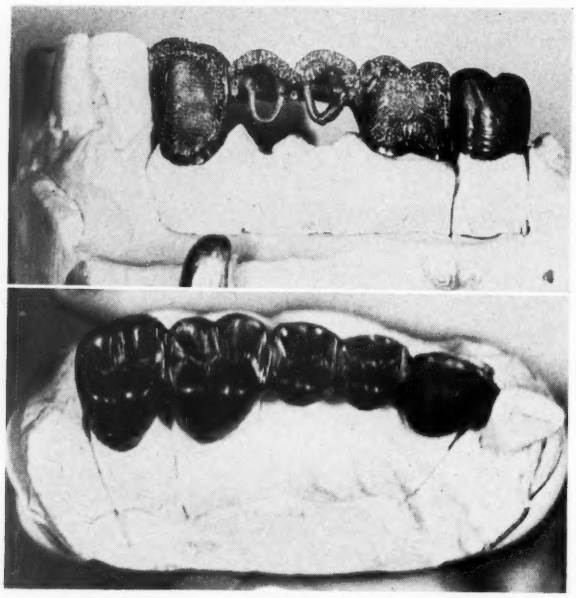


Fig. 6.

Fig. 5.—The bridge is waxed on the master cast.
Fig. 6.—The crowns and pontics are waxed together on the refractory cast. The pattern is ready for investing.

Fig. 7.

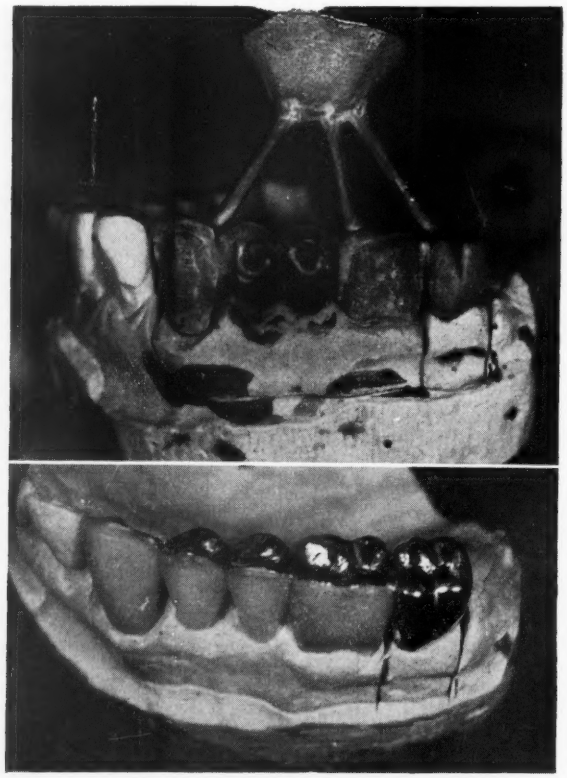


Fig. 8.

Fig. 7.—The casting is reseated on the master cast after being pickled and cleaned.
Fig. 8.—The completed fixed bridge.

together on the master cast. The contacts and occlusion are carefully checked as no metal will be added to the bridge after casting. The pattern is sprued, and the wax-up and dies are removed together from the master cast. The dies are then removed from the wax pattern, and the pattern is invested and cast. It is then returned to the master cast for finishing.

The procedure is necessarily different for larger bridges. Should an attempt be made to draw a larger wax-up from the cast, inaccuracies might result. An intervening step is necessary for these larger bridges. The master cast is removed from the articulator and duplicated. We use the same type of hydrocolloid in a tray to make an impression of the master cast (Fig. 3). A refractory cast is made in this impression with Cristobalite investment (Fig. 4). After the refractory cast has set, it is sprayed lightly with an acrylic resin spray. This serves to harden the surface of the cast and prevent it from being scratched or damaged.

The individual crowns and pontics are waxed and carved on the master cast (Fig. 5). After all the individual units are waxed, they are transferred to the refractory investment cast, and the margins are sealed. The wax units are joined together and the cast is prepared for investing and casting (Fig. 6). The casting is pickled and cleaned, and replaced on the master cast (Fig. 7). Since the master cast is a duplicate of the mouth, the bridge can be polished and completed (Fig. 8).

The temporary bridge is removed, and the abutment teeth are cleaned. The bridge will seat accurately, and is ready for cementation.

SUMMARY

A discussion of the advantages of one-piece castings has been presented, and the disadvantages of soldered contacts have been enumerated. A technique for the accurate casting of fixed bridges in one piece has been presented.

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THE IMPLICATIONS OF FULL COVERAGE RESTORATIVE PROCEDURES

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THE TERM "FULL COVERAGE" is used to describe the "new" and popular approach to crown and bridge abutment design. The purpose of this article is to call attention to the responsibilities of dentists in placing these radical restorations. The removal of all of the functional form of a tooth above the gingivae is radical technique, without question. Radical plans imply that an emergency is present. Calculated risks must be taken into consideration whenever an emergency exists.

My first paper on "Complete Crown Restoration" was presented in 1928. Since then, most of my writing, teaching, and practice has been on physiologic tooth form and restoration, with particular reference to complete crown functional form.

In thirty-five years of practice, I have seen many "fads" come and go. New techniques, materials, and equipment have had their effect on this. Of course, real contributions to dentistry may be made by such development, and stagnation of effort may be avoided. However, I am sorry to say that my observation is that new materials and equipment have had more bearing on changes than have new ideas and techniques. That is understandable, since the former can attract a "market" much more easily, and they may be discovered in an attractive background without studious effort.

The restoration of the complete crown is basic in rehabilitation, since it reproduces a unit in the dental arch. The multiplication of units can rehabilitate the dental mechanism completely.

"Full coverage" is *not* a passing fad, although the term is not good nomenclature. This method of restoration, properly consummated, is sound and has been proved satisfactory over the years.

The disturbing factor is the tendency, on the part of the profession, to use the treatment indiscriminately. Almost overnight, crown and bridgework has become popular, after being abandoned by most for a generation. Dental laboratories are being swamped by orders, without having enough trained technicians to take care of the volume, since they too, of necessity, neglected this department for years because of the lack of demand for it.

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WHY HAS THE COMPLETE CROWN TECHNIQUE BECOME SO POPULAR?

Some years ago, dentists avoided making complete crowns if a more conservative treatment could be used. Why has the attitude of a great part of our profession changed? There are six possible reasons:

1. Formerly, complete crowns took too much operating time, and sapped the energies of both the patient and the dentist. Carborundum stones and ordinary steels burs were inefficient. We said then that it seemed a shame to obliterate all that functional form unnecessarily.

2. Inlay techniques, materials, and equipment were popular. Many dentists were using inlays altogether for bridgework and individual restorations, even when complete crowns might have been indicated. The classic defense then was "conservation of tooth structure."

3. Inlays, overlays, and three-quarter crowns cut down the dentist's laboratory time required as compared with that for complete crowns. Good results could be obtained only by the dentist checking all patterns at the chair. It was not satisfactory to send the work to a laboratory.

4. Today, with every activity in daily living accelerated, we have been able to appropriate some industrial methods in dental practice. With the high speed techniques, we can now literally obliterate all of the tooth form we can see above the gingival line (as well as some below) in a matter of minutes; with the tooth under an anesthetic, of course.

5. Tapered preparations, with the use of very accurate new impression materials have enabled us to standardize the procedures, send the complete registrations to a laboratory, and have the finished work returned ready for seating, with the expectation that it will go to place.

6. We have been able, at last, to classify crown and bridge prosthodontics with partial and complete denture prosthodontics under the heading of "Dental Economics."

The following questions should be answered by every dentist using full coverage. Should this approach be a standard procedure? Should the process be used for *all* patients requiring extensive rehabilitation? Should the bridge abutments and anterior teeth be treated in this manner? What are the risks of full coverage?

It has always been possible to cut any tooth down for a crown, even by older and more crude methods. Therefore, there is nothing to prevent the dentist from doing it whenever he desires. Nevertheless, if it is done without discretion, the ethics of such practice could be questioned, as would be revealed by careful diagnoses of the needs of patients. It is not my intent to question or ridicule complete crown prosthesis. Acceptance of a radical operation as standard treatment is questioned.

Crown and bridge prosthesis probably requires more training and technical skill than most things we do. It is highly scientific, and deserves a careful diagnostic approach, along with considerable conscientious ability.

If the dentist has sufficient knowledge of any field of operation, and if he knows tooth form and function, he is bound to have a profound respect for every unit in the human dental mechanism, which is one of Nature's marvels.

If there are any dentists who would like to check on their qualifications, the following outline of basic training required for complete crown restoration will serve for this purpose. The outline has been proved many times in teaching.

COMPLETE CROWN RESTORATION

Basic Training as a Background for Operative Technique.—

A. Physiologic tooth form which serves to protect the periodontium;
   1. Proximal contact areas.
   2. Interproximal spaces.
   3. Embrasures.
   4. Labial, buccal, and lingual curvatures at the cervical thirds (cervical ridges) and at the middle thirds of crowns.
   5. Curvatures of the cervical line, mesial and distal. (These govern normal height of epithelial attachment.)

B. Physiologic form of the tooth to be restored:
   1. Five aspects of the crown and root.
      a. Design and location of contact areas.
      b. Design of cervical portions of both the crown and root. (Includes the cervical curvatures of cemento-enamel juncture.)
      c. Design of occlusal third of crown and occlusion with opposing teeth.
      d. Alignment in the arch.

C. References to the histology of the gums and gingivae:
   1. Exposure of clinical crown.
   2. Gingival crevice.
   3. Epithelial attachment.
      a. Attachment level.

D. Suggested references:
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The removal of all of the crown form of a tooth is a radical treatment. When one removes it, one takes the responsibility for its complete restoration. In the vernacular, "That is a large order." A tooth is enabled to function through its form alone. The relationship of that form to adjoining teeth and opposing teeth makes its stability possible, and preserves its position and attachment.

Surgeons risk the loss of prestige if they insist on radical surgery without the support of a thorough diagnosis which indicates the need. In fact, the history of medicine records periods of radicalism, followed by waves of public resentment

which are still reverberating somewhat in the public mind. For example, not too long ago, tonsils were removed indiscriminately. Severe stomach-aches, or even mild ones, could easily point to the patient's need for an appendectomy, and so on.

Is history repeating itself in dental circles? Is it possible that radical dental surgeons are advocating full coverage when a much more conservative treatment would suffice?

There is no argument against complete crown restoration after careful diagnosis and prognosis point to its requirement. However, the dentist must feel confident of good results before he acts. He must be sincere in the thought that when his work is finished the patient will have benefitted by the treatment; not be injured by it.

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MAINTENANCE OF FULL COVERAGE FIXED-ABUTMENT BRIDGES

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A FIXED PROSTHESIS is a good practical restoration for the missing space in a patient's dental arch. The patient is usually more comfortable with this type of replacement than with a removable clasp-type restoration. The full coverage abutment restoration is dependable for indefinite retention of the prosthesis.

The full cast crown has been found to be the most dependable type of retainer. It is ideal as an abutment for a fixed bridge, for a tooth that is to be used for a clasp for a removable partial denture, and for the restoration of badly broken down teeth. However, it has a disadvantage in that it is difficult to detect caries at the gingival margins of the restoration. In the inlay type of retainer, much of the coronal surface of the tooth is exposed to view and is seen easily in the course of examination. Decay around the margins of an inlay is readily detected. The margins of a cast crown are usually located in the gingival sulcus and are not exposed. Caries can begin, and proceed to destroy the abutment tooth without the patient being aware of it. Sometimes caries continues until the pulp of the abutment tooth is involved.

A tooth with a cast crown of the modern type is more subject to decay than one that is prepared for a shell crown. This is because, in the preparation for a shell crown, the tooth is not always stripped of its enamel. The remaining enamel acts more as a protection against the attack of caries than the dentine of a properly prepared abutment tooth. Decay progresses much more rapidly in dentine than in enamel.

EXAMINATION FOR DECAY

Simpson[1] stated that the dental roentgenogram is a valuable adjunct in the examination of the teeth. He also stated, however, that after the roentgenographic examination, the careful operator should test every surface of every tooth with a very sharp explorer.

This is difficult in the mouths of some patients who have a low threshold of pain sensitivity. It may be necessary to anesthetize doubtful teeth in order to run the explorer over these hypersensitive areas for the detection of possible decay.

When examining roentgenograms of teeth with cast crowns, particular attention should be paid to the cervical margins. Any indication of radiolucency in this

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area should be noted and checked in the mouth. Quite often, mesial or distal caries can be seen in the dental roentgenograms, but caries is not always seen on the buccal or lingual surfaces. This would have to be detected with the explorer.

If caries is noted in an inaccessible area, it would be best and safest to remove the crown, excavate the decay, and make a new restoration.

Fortunately, however, most of the areas of caries are accessible. If there is the slightest doubt in the operator's mind as to whether he can remove the decay completely, it is advisable to remove the crown.

REMOVAL OF CARIES

The removal of caries is begun by the use of a diamond-wheel stone to make the initial penetration into the abutment crown and into the tooth structure at the cervical margin. By means of occlusal pull on the stone, the gold of the abutment crown can be cut readily and satisfactorily.

According to Schorr,[2] the accessibility to the carious lesion is enhanced by exposure of a large area. The use of a rather large bur (No. 4 seems large enough for most cervical caries) run over the area until solid tooth structure is reached is his preferred method for the removal of the decay.

If the cavity extends gingivally to a position where the gingival tissue interferes with the complete removal of the decay, two procedures are possible:

1. The excision of the overlying gingival tissue, and packing the area temporarily with baseplate gutta-percha or a zinc oxide-eugenol pack.

2. The making of a mucoperiosteal flap by making two diverging incisions extending apically from the gingival surface of the tooth to be operated on (one on the mesial, the other on the distal). The flap is retracted from the area with a periosteal elevator. A rubber dam is then applied with one punch hole for the affected tooth. A cervical clamp is applied, and the decay is removed, and the tooth is dried and sterilized.

TREATMENT OF EXCAVATED CAVITY

Seltzer[3] advised that the freshly cut cavity be dried and swabbed with Morson's creosote. The excess medicament is then absorbed with cotton. If the carious lesion is shallow, Copalite varnish should be applied, and an amalgam filling should be placed and contoured properly.

If the cavity is deep, a thin coating of either Vitec or Rower's calcium hydroxide paste should be applied to the pulpal wall with a wire-loop applicator and allowed to dry. A thick mix of oxyphosphate of zinc cement is applied as a base over this, and allowed to set. The margins of the cavity are planed clean and smooth. The cavity is undercut with an inverted cone or wheel bur, and a well-condensed amalgam filling is inserted. This is polished subsequently at a later sitting.

PREVENTION OF CERVICAL CARIES

Clayman[4] feels that much cervical decay around cast crowns can be eliminated if the casting is made without butt joints. If a cervical shoulder or chamfer is used, the gold should extend beyond the shoulder and a lap joint should be made. In making the preparation for a crown when cervical decay is removed and filled with cement, it is necessary to have the cervical margin of the gold extend well beyond the cement.

SUMMARY

The full cast crown has a disadvantage in that it is difficult to detect caries at the gingival margins of the restoration, while decay around the margins of an inlay is readily detected. The tooth with a cast crown of the modern type is more subject to decay than one prepared for a shell crown, because in the preparation for a shell crown the tooth is not always stripped of its enamel.

Caries on the buccal or lingual surfaces of teeth with full crowns is not always seen by direct vision or in roentgenograms. Caries in these locations must be detected with an explorer. If caries is noted in an inaccessible area, it is best and safest to remove the crown, excavate the decay, and make a new restoration.

If the cavity extends gingivally to a position where the gingival tissue interferes with the removal of the decay, two possible procedures are suggested. The treatment of the excavated cavity is described.

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The Readers' Round Table

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EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In the July, 1955, issue of your JOURNAL [5:538-542], a paper appeared entitled "The Relation of New Knowledge of the Gingiva to Crown and Bridge Procedures," written by David A. Hagerman and Sumter S. Arnim.

This article is apt to create a confusion in the minds of those who are not familiar with the problem, so a few words of clarification are needed. The authors write: "Recent investigations by Waerhaug reveal the need for complete re-evaluation of accepted theories concerning the relation of the marginal gingiva to the tooth . . . ." Further, "Conclusions drawn from his (Waerhaug's) comprehensive studies indicate that no firm organic union exists between the free gingiva and tooth surface, but that Black's concept is on the whole correct." We also read: "Zander made a significant contribution to knowledge of the gingiva by inserting acetate strips . . . . . His work supports and enlarges that of Waerhaug."

I am sure that it would have been much better in every respect if the authors had taken the trouble to assure themselves whether or not the theories advanced by Waerhaug are correct before jumping overboard with their conclusions. The conclusions of Waerhaug with regard to the epithelial attachment are entirely unwarranted and unproved by his experiments. The time is very near that we can discuss this "new knowledge" on the basis of experimental evidence. But to accept it as "new knowledge" and develop new ideas for those practicing prosthetics is not what would be called scientific.

Zander's contribution to this problem is significant! The use of the so-called mylar strip in a pocket to establish a true relation between the bottom of the pocket and epihelium is a very useful method. However, there is no "support" and "enlargement" to Waerhaug's concept, whatsoever, in the Zander experiment! In fact, I have several of Zander's specimens and have examined them with Zander, so I do not know where Hagerman and Arnim take their conclusions that Zander's experiment substantiates Waerhaug's. Waerhaug created such a confusion with his "new" concept that it will take quite some time to straighten out the thinking of many on this subject. There is no doubt in my mind that Waerhaug, in his studies, established a preconceived idea that there is no epithelial attachment. He then went to work to prove to himself that this concept was true. To those who did no work in this field, his book on the subject and his eight years of research are impressive enough that they feel there is something substantial presented. Unfortunately, the entire concept of Waerhaug is built on a cloud of imaginary findings which cannot be substantiated. The bandwagon that some of our colleagues have jumped upon will prove itself very soon to be a magic carpet of imagination, and, in some instances, wishful thinking.

The idea of Hagerman and Arnim that the "free gingiva" (a term used in the wrong sense by the authors) is endowed with the physiologic attributes common to mucous membranes found elsewhere in the human body sounds very attractive; but where else in the body have Hagerman and Arnim found a mucous membrane in relation to a calcified, hard structure like the tooth? Around the tooth, we are dealing with a unique situation, and only experimental and other scientific investigations can open up the secrets of nature to us. Imagination only helps when there is a sound foundation for it present in the investigator's mind.

Sincerely yours,
B. ORBAN, M.D., D.D.S.

OWEN SOUND, ONT.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

As a new subscriber—my first copy of the JOURNAL was the July issue—I judge from the JOURNAL that letters or comments are not encouraged, but that scientific articles are. For the above reason I wish to offer a paper on prosthetic dentistry under the heading: A General Practitioner Views Denture Prosthesis as a Science in Practice.

The late Rudolph Hanau expressed astonishment in his book on technique that only 5 per cent of the dental profession was practicing denture prosthesis as a science. It is only a guess, but I think his estimate today could be halved. One wise man, referring to another science, said, "It takes a lot of learning to get away from the simple truth." It seems to me this remark is just as applicable to the subject of prosthetics. One sees numerous articles in the journals—THE JOURNAL OF PROSTHETIC DENTISTRY is no exception—where the approach has been through physiology, anatomy, etc., and invariably the writers end in the abyss. What they write is learned enough, their syntax is good, but their subject matter is nonsense as far as the practice of prosthetics as a science is concerned. I will enlarge on this statement later.

The following are two statements of mine on technique:

1. (A) This mounting of the upper cast on an adjustable articulator (the Hanau) by means of the face-bow, is the first and most important step in the technique. What follows is orderly, rational, and scientific procedure. Hanau states that the position of the upper cast when mounted according to his technique is exact within minute fractions of an inch. To me, this means that in comparison with what is found in the anatomy, there is no distortion anteroposteriorly or vice-versa, laterally right or left, or torsionally. This part of the technique is the work of the basic scientists, for example Snow, and in my opinion is the crux of the whole procedure. I think this work of Snow's was inspired. Yet, these writers who approach the subject through physiology and anatomy merely gloss over this part, if they mention it at all.

(B) The arbitrary mounting of the casts on an articulator built to mechanical principles only is the method of the craftsman and is a rational procedure. It is also the most popular one, from the beginning of the world to the date hereof.

(C) The arbitrary mounting of the casts on the precision instrument is nonsense.

2. In partial denture prosthesis, it is necessary to establish the jaw relation before designing and surveying the cast (or casts) on which the denture is to be made. If this procedure is not followed, the survey will be an arbitrary one. When the jaw relation is later established on a precision instrument, this arbitrary survey will place excessive torque on the abutment teeth and shorten the life of the denture. The writers who are advising their readers that they "must visualize the anticipated stresses resulting from the chewing cycle of the individual," and design the restoration accordingly, are advocating an arbitrary design and survey. The above quotation appeared in an article in your JOURNAL sometime ago [J. PROS. DEN. 3:493, 1953], and was reprinted in the Ontario Dental Journal. The writer would hardly be using a mechanical articulator. So, in effect, he is telling his readers that they must visualize the stresses in the chewing cycle, then establish the jaw relation on a precise instrument which allows no distortion of the cast (or casts) and has a limited movement of four to six millimeters, and he expects that what he has visualized (and remember, when he visualized it, it was not actually in existence) will be in harmony with the patient's jaw movements. Do you sense the abyss?

Sincerely yours,

H. A. HARTFORD, D.D.S.

BROOKLYN, N. Y.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

Dr. Hartford's notation that dentists should not advocate an arbitrary design and survey is well taken. We should not stray too far toward either the physiologic or the mechanistic pole. Our aim should be the synthesis of both viewpoints. The basic idea expressed in the quotation from my article that dentists "must visualize the anticipated stresses resulting from the chewing cycle of the individual . . ." refers to planning the placement of clasp parts so that they will function to best advantage during chewing.

Surveying is a procedure for seeking suitable surfaces for clasp design. Its purpose should be deeper than that. When the dentist designs a partial denture, the essential supportive, retentive, and stabilizing elements for this patient are incorporated in the frame in accordance with the orthodox chewing cycle. However, if this patient's habitual chewing patterns differ from the usual, some change in design would be required. For example, stabilizing elements planned to resist buccolingual stresses might be of little or no value in the same mouth if the chewing stroke is relatively vertical. If the dentist were to discover this fact at the time of clinical evaluation, he might then seek, in his survey and design planning, to make relatively stronger vertical supportive elements, and reduce the horizontal stabilizers. The value of studying the chewing cycle as an adjunct to partial denture planning should be clear from this example alone.

A physiologic approach is not a substitute for any of the ordinary mechanical procedures used by the dentist. The purpose of partial denture case analysis as outlined in a subsequent article (J. PROS. DEN. 4:82, 1954) is to help the dentist to *think*.

Cordially,

JOEL FRIEDMAN, D.D.S.

News and Notes

ANNOUNCEMENTS

The Midwinter Meeting of the American Denture Society will be held at the Congress Hotel, Chicago, Ill., Feb. 3 and 4, 1956.

The next annual meeting of the American Academy of Restorative Dentistry will be held at the Conrad-Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1956.

The next annual meeting of the American Academy of Crown and Bridge Prosthodontics will be held at the Conrad-Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1956.

The 14th Annual Mid-Continent Dental Congress will be held at the Jefferson Hotel in St. Louis, Nov. 27-30, 1955. A large part of the program is to be devoted to prosthodontics. For further information, write to the St. Louis Dental Society, 8013 Maryland Ave., St. Louis 5, Mo.

A two day meeting of The Greater New York Academy of Prosthodontics will be held at the New York University College of Dentistry, 209 E. 23rd St., New York, N.Y., on Dec. 3 and 4, 1955.

Northwestern University announces fifteen short postgraduate courses to be given during the academic year 1955-1956. Courses in Operative Dentistry, Oral Surgery, Periodontia, Orthodontics, Pedodontics, Crown and Bridge, Pathology, and Histology are included, as well as specific courses in diagnosis and medical problems in relation to dentistry. The courses will be given by prominent dental teachers from the faculties of Northwestern University Dental School and other well-known dental schools, and by prominent clinicians.

The dates of the courses and other detailed information can be obtained by addressing the Director of Dental Postgraduate Study, Northwestern University Dental School, 311 E. Chicago Ave., Chicago 11, Ill.

The Medical College of Virginia, School of Dentistry, announces a series of postgraduate courses of interest to general practitioners. These courses are given by the members of the faculty, unless otherwise designated.

Partial Denture Design, Vincent R. Trapozzano	Jan. 16-21, 1956.
Complete Denture Construction, Vincent R. Trapozzano	Jan. 23-28, 1956.
Crown and Bridge Prosthesis	Feb. 20-22, 1956.
Periodontics	March 5-9, 1956.
Oral Diagnosis	March 12-17, 1956.

Anatomy of the Head and Neck	March 19-23, 1956.
Oral Surgery	April 9-11, 1956.
Roentgenology	April 16-18, 1956.

For further information, write to S. J. Kreshover, Director of Postgraduate and Graduate Instruction, Medical College of Virginia, School of Dentistry, Richmond 19, Va.

Tufts University School of Dental Medicine announces the following postgraduate courses:

D.P.G. 603—Temporary Splinting and Minor Tooth Movement in the Management of Periodontal Problems, Leonard Hirshfeld, Jan. 16-18, 1956.

D.P.G. 703—Full Denture Implants, Norman I. Goldberg and Aaron Gershkoff, Jan. 9-13, 1956.

For further information and application write to the Director, Division of Graduate and Postgraduate Studies, Tufts Dental School, 136 Harrison Ave.. Boston, Mass.

New York University College of Dentistry announces three postgraduate courses in Periodontia and Oral Medicine, by Dr. Samuel Charles Miller and Staff.

No. 124—Refresher Course in Periodontia and Oral Medicine. Each Wednesday, 4 to 6 P.M., Feb. 29-May 10, 1956.

No. 123—Periodontia and Oral Medicine in the Spanish Language, April 2-27, 1956.

No. 122—Comprehensive Preparation in Periodontia and Oral Medicine. This program is arranged in from one to four academic years.

For further information concerning these courses, write to the Secretary, Postgraduate Division, New York University College of Dentistry, 209 E. 23rd St., New York 10, N. Y.

The School of Dentistry, University of Pennsylvania, announces the following postgraduate courses:

Oral Diagnosis and Roentgenology, Lester W. Burket, Jan. 2-13, 1956.

Precision Prosthesis and Functional Treatment, Ernest R. Granger, Jan. 16-21, 1956.

Hydrocolloid Indirect Technic for Inlays and Bridges, Morris J. Thompson, Feb. 11-12, 1956.

Oral Surgery and Anesthesia, Thomas M. Meloy, Feb. 20-25, 1956.

Periodontal Prosthesis, Morton Amsterdam and D. Walter Cohen, Feb. 27-March 3, 1956.

Crown and Bridge Prosthesis, Charles B. Sceia, March 5-10, 1956.

Complete Denture Prosthesis, M. M. DeVan, March 12-17, 1956.

Complete Denture Prosthesis, Victor O. Lucia, March 19-24, 1956.

Endodontics, Louis I. Grossman, April 12-27, 1956.

The Seventh Mid-Atlantic States Conference in Dentistry, Skytop Lodge, Skytop, Pa., Periodontal Prosthesis, Lester W. Burket, April 22-27, 1956.

For further information concerning these courses please communicate with Postgraduate Courses, School of Dentistry, University of Pennsylvania, Philadelphia 4, Pa.

The Ohio State University College of Dentistry announces a series of postgraduate courses to be presented during the 1955-1956 school year. The enrollment of each course is limited, in order to permit intimate teaching.

The schedule of these postgraduate courses is as follows:

Anatomy of the Head and Neck, Dr. Linden F. Edwards, June 11-15.

Clinical Oral Pathology and Diagnosis, Dr. Hamilton B. G. Robinson, Feb. 13-17.

Clinical Periodontics, Dr. John R. Wilson, June 11-15.

Complete Denture Prosthodontics, Dr. Carl O. Boucher, Dec. 5-9, 1955, Feb. 20-24, and April 9-13.

Crown and Bridge, Dr. Frank C. Starr, April 2-6.

Endodontics, Dr. J. Henry Kaiser, March 5-9.

General Anesthesia, Dr. M. L. Allison and Staff, May 21-25.

New Advances in Restorative Dentistry, Drs. William Lefkowitz, Harry Postle, and Mr. Ralph Phillips (Indiana University), May 10-12.

Oral Surgery, Dr. M. L. Allison and Staff, April 30-May 4.

Partial Denture Prosthodontics, Dr. Victor L. Steffel, March 26-30.

Pedodontics, Drs. L. S. Pettit and Ben Williams, May 14-18.

Periodontology and Soft Tissue Lesions, Drs. Hamilton B. G. Robinson and John R. Wilson, June 4-8.

For further information and application, write to Postgraduate Division, College of Dentistry, Ohio State University, Columbus 10, Ohio.

Directory

OFFICERS OF THE ORGANIZATIONS WHICH HAVE THE JOURNAL OF PROSTHETIC DENTISTRY AS THEIR OFFICIAL PUBLICATION

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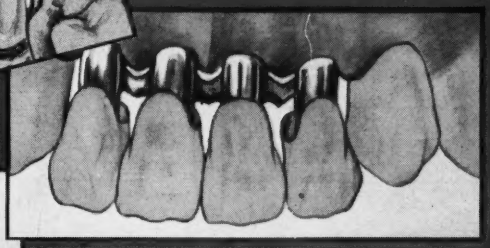

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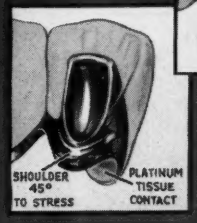

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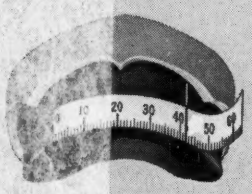

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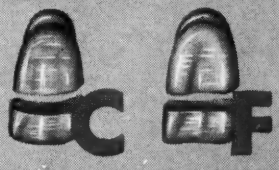

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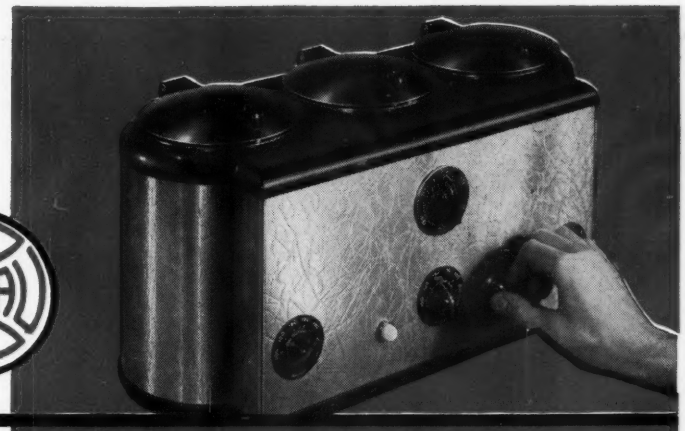

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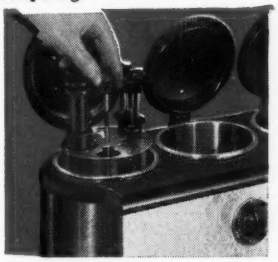

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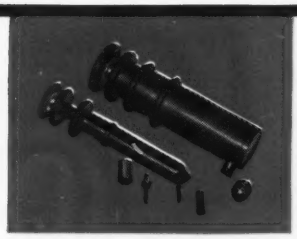

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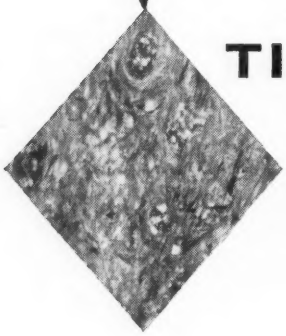

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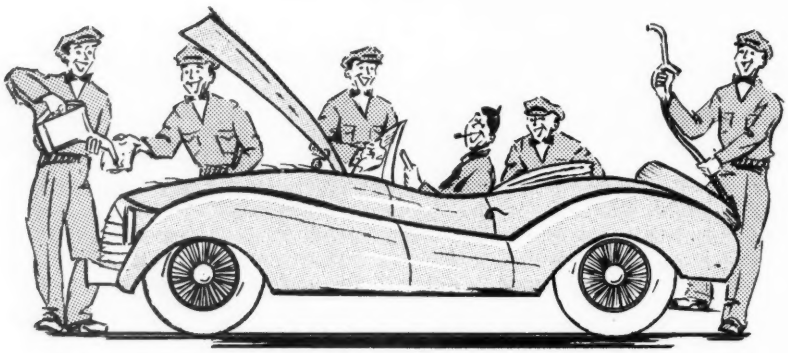

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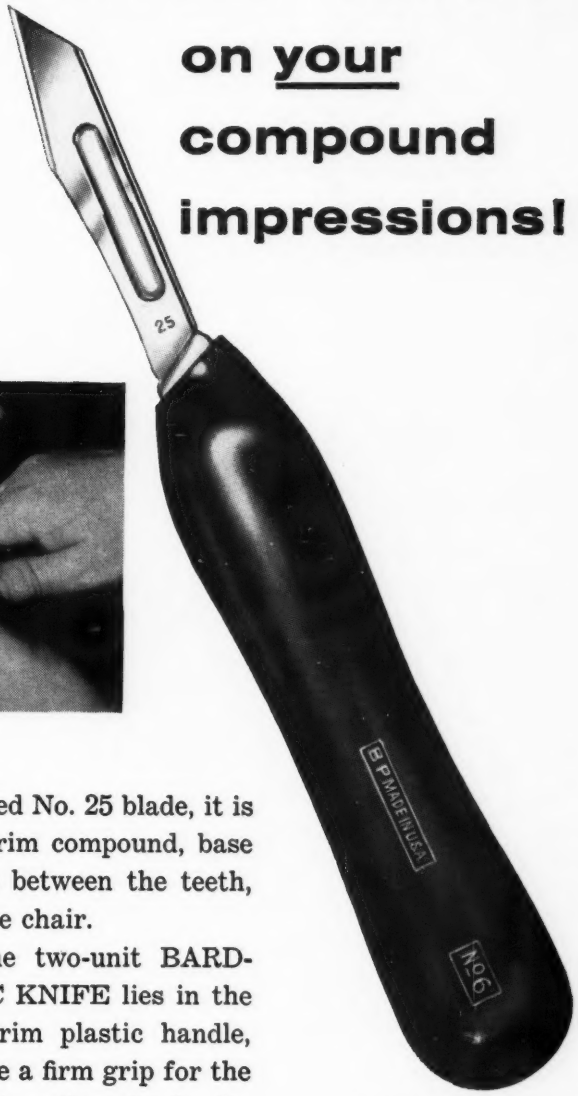

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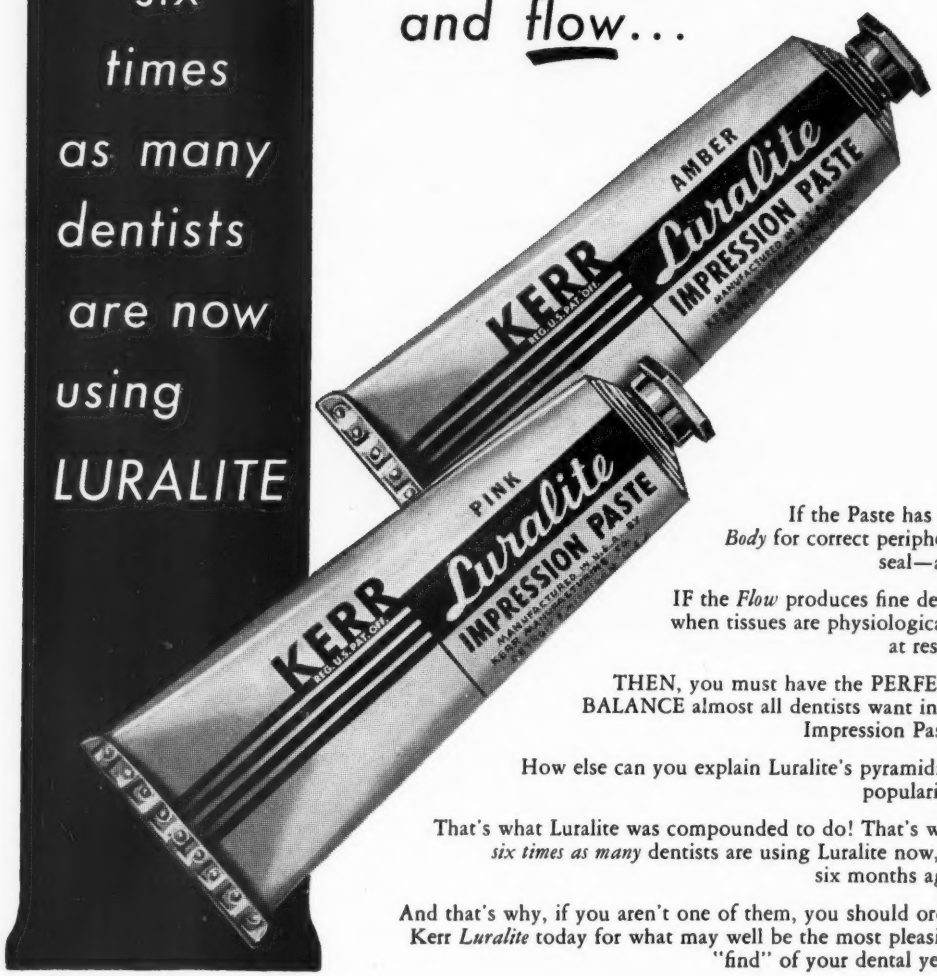

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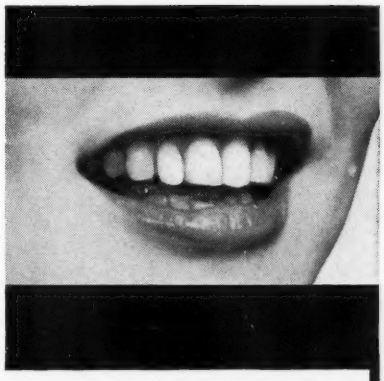

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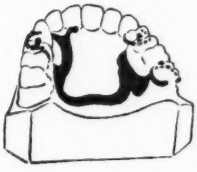

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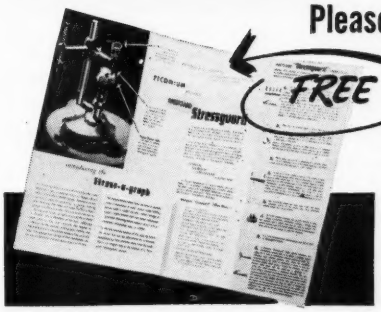

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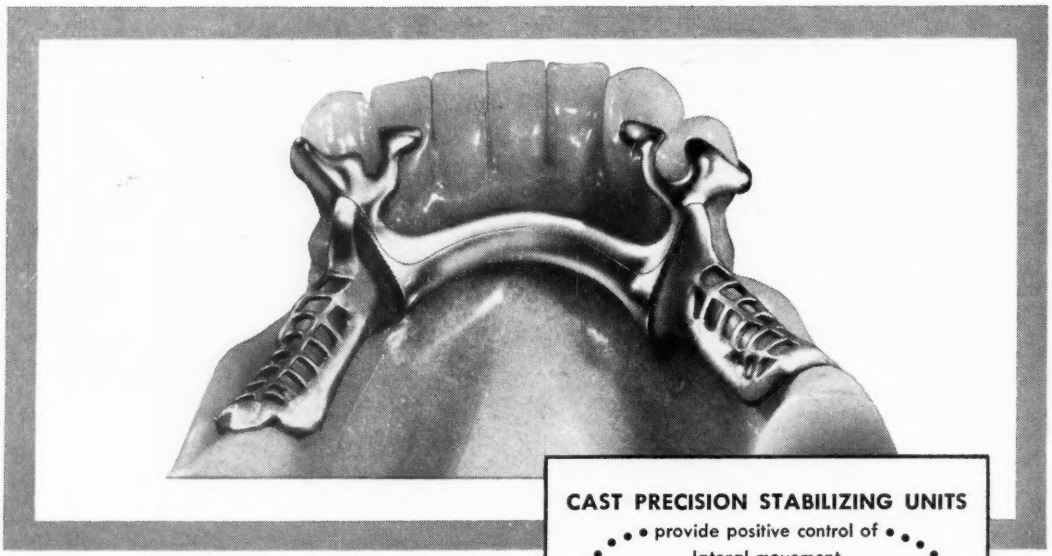

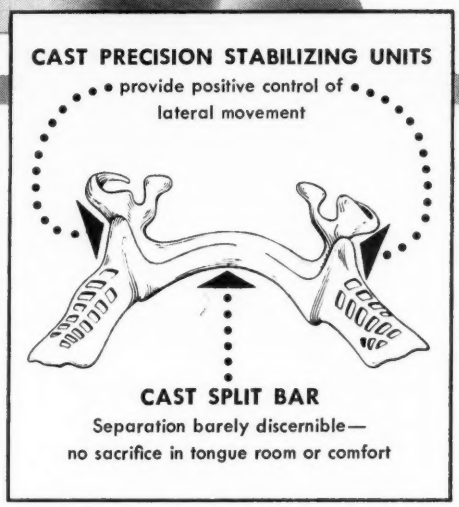
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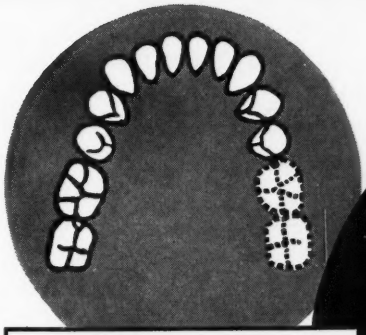
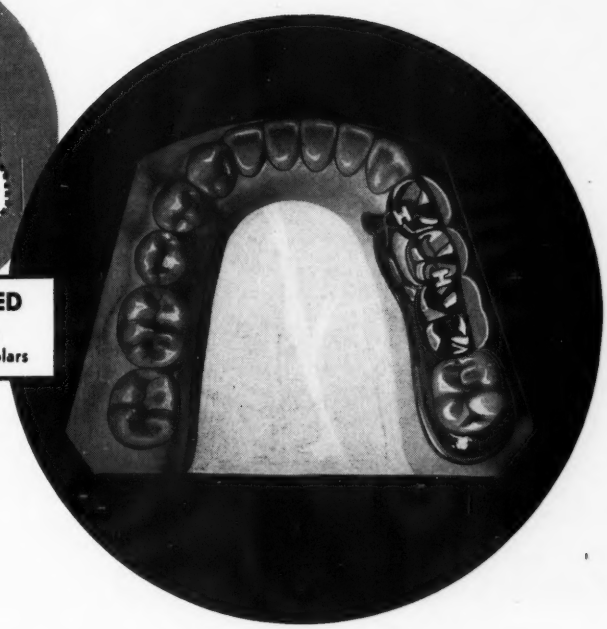
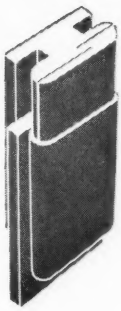




THE CASE AS PRESENTED

A difficult unilateral restoration replacing lower first and second molars



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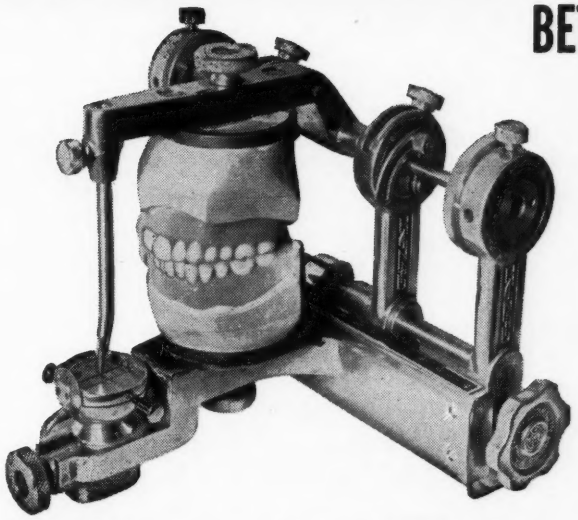

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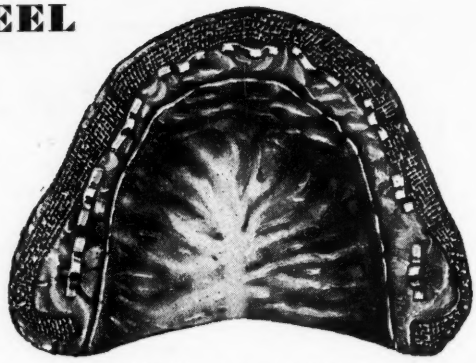

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	Page
Bailey Dental Laboratories, Gordon (Swissedenture)	6
Bard-Parker Company, Inc. (Prosthetic Knife)	13
Boos Dental Laboratories, Inc., Henry P.	16
Cosmos Dental Products, Inc. (Densen Muco-Tone)	11
Dental Gold Institute, Inc. (Gold)	8
Dentists' Supply Company of New York (Biotone)	Fourth Cover
Detroit Dental Clinic Club	22
Hanau Engineering Company, Inc. (Hydrocolloid Conditioner)	7
Hudson Products, Inc. (Polident)	1
Jelenko & Company, Inc., J. F. (Firmilay)	Second Cover
Kerr Manufacturing Company (Luralite)	14
Lamb Dental Laboratory, Chauncey H. (Dentures)	19
Ney Company, The J. M. (Gold)	9
Nudell, Uza (Swaged Dentures)	22
Nu-Dent Porcelain Studio, Inc. (Porcelain Restorations)	3
Stern Goldsmith Corporation (Precision Attachments)	17
Ticonium (Stressguard)	15
Ticonium (Tilon)	10
Toff, Maurice (Reconstruction Materials)	12
Universal Dental Company (Five-Phase Anteriors)	4 & 5
Wernet Dental Manufacturing Company, Inc. (Dental Powder)	Third Cover
White Dental Mfg. Co., The S. S. (Oraline)	19

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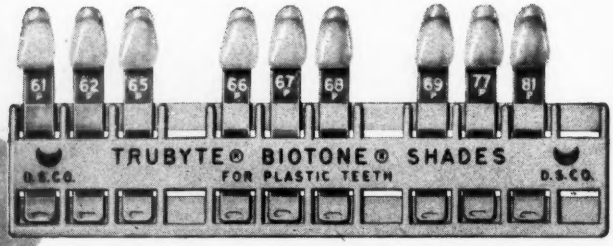
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